

AD-A168 098

AN ANALYSIS OF AIRCREW RATIOS IN STRATEGIC AIRLIFT - A

1/2

SLAM SIMULATION(U) AIR FORCE INST OF TECH

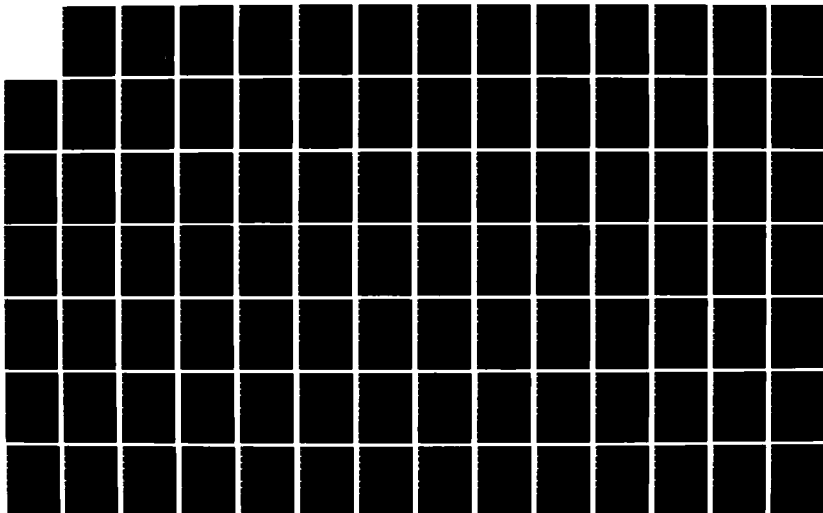
WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING

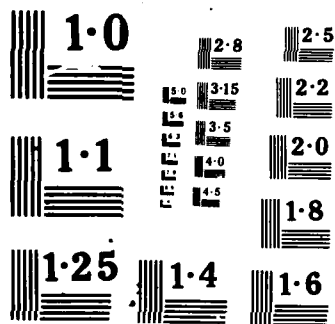
UNCLASSIFIED

B L SUTTER DEC 85 AFIT/ENS/GOR/850-19

F/G 5/9

NL





NATIONAL BUREAU OF S
MICROCOPY RESOLU1 TEST

(1)

~~AFIT/ENS/GOR/85D-19~~
~~AFIT/DDR/ENG/85B-18~~

AD-A168 098

AN ANALYSIS OF AIRCREW RATIOS
IN STRATEGIC AIRLIFT --
A SLAM SIMULATION

THESIS

Brian L. Sutter
Captain, USAF

~~AFIT/EN/GOR/85B~~

AFIT/ENS/GOR/85D-19

DTIC
ELECTE

MAY 28 1986

B

Approved for public release; distribution unlimited

86 5 12 044

~~AFIT/ENS/GOR/85D-19~~
~~AFIT/DDR/ENS/85D-19~~

AN ANALYSIS OF AIRCREW RATIOS
IN STRATEGIC AIRLIFT --
A SLAM SIMULATION

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Operations Research

Brian L. Sutter, B.S.

Captain, USAF

December 1985

Approved for public release; distribution unlimited

Preface

The purpose of this study was to develop a simulation model for helping Air Force decision makers to choose optimal ratios of aircrews to aircraft. The immediate need for this model is in evaluating crew ratios for MAC's new airlifter, the C-17; but the approach should be valid for any strategic airlift aircraft.

The model primarily measured four attributes: aircraft utilization rate, average monthly flying time, average work month, and average time away from home station. Second order regression equations were also derived as estimators of the first three of these measures.

Sensitivity analysis was performed on various crew ratios, target utilization rates, flying time limits, and staging policies. The results seemed plausible, but analysis should continue. The study could be of significant value to planners at HQ MAC and the Air Staff.

In performing the modeling, experimentation, and writing of this thesis, I had a great deal of help from others. I am deeply indebted to my faculty advisor, Lt Col Charles Ebeling, for his continuing patience and assistance. His high standards and insistence on an operationally useful model has set an ideal for future studies. I also wish to thank Capt David Tate at Studies and Analysis and Maj Wayne Stanberry and Maj Glen Moses at HQ MAC for assistance

throughout the project. Finally, I wish to thank my wife, Linda, and daughters for their understanding and concern during the entire eighteen months at AFIT.

Brian L. Sutter

Approved	✓
PER CALL JC	
Dist	
A-1	



Table of Contents

	Page
Preface	ii
List of Tables.	vi
List of Figures	viii
Abstract.	x
I. Introduction	1-1
General Issues	1-1
Objectives.	1-1
Scope and Limitations	1-2
Historical Background	1-3
Overview	1-7
II. Model.	2-1
SLAM Background	2-1
Narrative Description	2-2
SLAM Network.	2-4
FORTRAN Events	2-8
Input Data and Assumptions	2-10
Output	2-13
III. Methodology.	3-1
Warmup and Phase Transition	3-1
Experimental Factors	3-2
Measures of Effectiveness.	3-5
Model Verification and Validation	3-6
Design	3-7
IV. Analysis and Results.	4-1
Initial Screening Results.	4-1
Regression Analyses.	4-5
Subsequent Runs.	4-5
Regression Results.	4-7
Confidence Limits	4-15
Sensitivity Analysis	4-16
Crew Ratio Sensitivity	4-16
Staging Policy Sensitivity	4-22
Target Utilization Rate Sensitivity	4-24
Fly Time Limit Sensitivity	4-26

U.	Observations and Recommendations.	S-1
	Observations	S-1
	Future Studies	S-2
Appendix A:	Model Flow Charts	A-1
Appendix B:	SLAM Network Code	B-1
Appendix C:	FORTRAN Main	C-1
Appendix D:	Scenario Files	D-1
Appendix E:	Simulation Output	E-1
Appendix F:	Multi-Base SLAM Network Code.	F-1
Appendix G:	FORTRAN Main for Multiple Homebase.	G-1
Appendix H:	Scenario Extracts	H-1
Appendix I:	ANOVA	I-1
Appendix J:	Regression Analysis.	J-1
Appendix K:	Sensitivity Results.	K-1
Bibliography		BIB-1
Uita		UIT-1

List of Tables

Table	Page
2.1 Crew Related Characteristics.	2-14
2.2 System Related Characteristics.	2-14
3.1 Experimental Factors	3-3
3.2 1/4 Replication of 8 Factors	3-8
4.1 Analysis of Variance--AUR	4-2
4.2 Analysis of Variance--AUGWORK	4-3
4.3 Analysis of Variance--AUGFLY	4-4
4.4 Composite Levels	4-6
4.5 Regression Results--Average Work Month	4-8
4.6 Regression Results--Average Fly Time	4-10
4.7 Regression Results--Achieved Utilization Rates	4-11
4.8 Variable Ranges for Regressions	4-12
H.1 NATO Single Homebase Scenario	H-1
H.2 SWA Single Homebase Scenario	H-2
H.3 NATO Multiple Homebase Scenario	H-3
I.1 Anova Data	I-1
J.1 Center Point and Axial Data.	J-1
J.2 BMDP Regression Results for AUR (SWA)	J-3
J.3 BMDP Regression Results for AUR (SWA)-Revised.	J-7
J.4 BMDP Regression Results for AUR (NATO)	J-10
J.5 BMDP Regression Results for AUGWORK (SWA)	J-11
J.6 BMDP Regression Results for AUGWORK (NATO).	J-12
J.7 BMDP Regression Results for AUGFLY (SWA)	J-13

Table	Page
J.8 BMDP Regression Results for AUGFLY (NATO) . . .	J-14
K.1 Crew Ratio Sensitivity	K-1
K.2 TUR Sensitivity.	K-3
K.3 Flytime Limits Sensitivity	K-4
K.4 Staging Policy Sensitivity	K-5

List of Figures

Figure	Page
2.1 Model Flow.	2-3
4.1 Lack of Fit Analysis for AUR Response Functions .	4-13
4.2 Lack of Fit--AUR Revised	4-14
4.3 Effect of CR (4.0,4.2,4.4) on AUR (NATO). . . .	4-17
4.4 Effect of CR (4.6,4.8,5.0) on AUR (NATO). . . .	4-18
4.5 Effect of CR on Avg. Work Month (NATO)	4-19
4.6 Effect of CR on Avg. Mo. Fly Time (NATO). . . .	4-20
4.7 Effect of CR on Time Away From Station (NATO) .	4-21
4.8 Effect of Staging Policy on Ute Rate (NATO). . .	4-22
4.9 Effect of Staging Policy on Work Month (NATO) .	4-23
4.10 Effect of Staging Policy on Avg. Mo. Fly Time (NATO)	4-23
4.11 Effect of Target Ute Rate on Achieved (NATO) . .	4-24
4.12 Effect of Target Ute Rate on Work Month (NATO). .	4-25
4.13 Effect of Target Ute Rate on Avg. Mo. Fly Time (NATO)	4-25
4.14 Effect of 30/90 Day Limits on Achieved Ute (NATO).	4-26
4.15 Effect of 30/90 Day Limits on Work Month (NATO) .	4-27
4.16 Effect of 30/90 Day Limits on Avg. Mo. Fly Time (NATO)	4-27
A.1 Flow Diagram-Generation	A-2
A.2 Flow Diagram-Crew Rest & Preflight.	A-3
A.3 Flow Diagram-Enroute Base.	A-4
A.4 Flow Diagram-Termination	A-5
J.1 Residual Plot--AUR	J-5

Figure	Page
J.2 Normal Probability Plot--AUR.	J-6
J.3 Residual Plot Revised	J-8
J.4 Normal Probability Plot Revised.	J-9

Abstract

This investigation examined the C-17's mission capability in terms of each aircraft's utilization and that utilization's effect on the aircrew. Specifically, average monthly flying times and average work months, as well as aircraft utilization, were found to be affected by changes in flying time limits, staging policies, target utilization rates, the number of crews, and the launch reliabilities.

The analysis was accomplished through a ^{using TSP - based} SLAM simulation ^{language} of a portion of the MAC airlift system. A single homestation and two homestations were modeled; however, only the single homestation model was analyzed. The output of the simulation was regressed to yield an estimating equation for achieved utilization, average monthly flying time, and average work month for both a NATO and a SWA scenario.

Parameters varied in the sensitivity analysis were crew ratios, target utilization, monthly and quarterly flying limits, and staging policies. Results pointed toward 4.8 crews per C-17 without considering the cost tradeoffs. Staging one crew at an enroute base for every forty-five planned mission transits seemed to be optimal. The results also showed a significant benefit in the sustained phase when the 30/90 day limits were raised to 150/450 hours.

I. Introduction

General Issue

The Air Force doctrine states that the United States Air Force "must be able to surge and expand to any part of the globe within hours" (8:5). In order to accomplish this mission, Military Airlift Command (MAC) plays a vital role -- that of transporting the troops and equipment. If this mission can be accomplished with one less crew per aircraft, MAC can save approximately \$1.526 billion (17). This, in fact, was the justification in the 1985 budget process for funding a 4.0 crew ratio for the new C-17 as opposed to the proposed 5.0.

HQ MAC and Air Force Studies and Analysis need a model for determining mission capability given the number of authorized crews and the impact of changing that number. They need a model that is capable of answering such "What if?" questions as: What is the impact on aircraft utilization if monthly and quarterly flying time limits are raised?

Objectives

The purpose of this research is twofold: 1) to provide a prediction equation that will give decision makers a quick answer as to the utilization rates of their aircraft that can be expected given certain system characteristics, and 2) to provide a model that can show, in a dynamic manner,

results when parameters are varied and is flexible enough to be applied to various aircraft and/or scenarios.

Air Staff and HQ MAC planners do not currently have an adequate, portable (capable of being used at more than a single location) methodology for assessing mission capability. This study will address the capability of MAC to accomplish its mission given a specific scenario and associated aircrew, aircraft, and system characteristics.

In order to make this determination, the following subsidiary questions must be answered:

1. How does an aircraft flow through the airlift system?
2. How does an aircrew flow through the airlift system?
3. What input parameters need to be considered in determining aircrew ratios?

Scope and Limitations

This study will address MAC's intertheater (between theater) airlift. The specific aircraft referenced will be the C-17, although it could be any aircraft currently in the Air Force inventory or a future acquisition, assuming its characteristics are known.

MAC plans for two different types of contingencies, surge and sustained, each lasting forty-five days. Typically, sustained operation has driven the crew ratios because of the high utilization rates, maintenance "catch up" from surge, and tired aircrews. Recently, concern has also been increasing over peacetime capability and transition into

surge. This study will model forty-five days of both surge and sustained as well as forty-five days of peacetime operation.

To maintain a manageable model, only major factors will be addressed. Air refueling will not be addressed to reduce scenario complexity and because SAC support is uncertain at this time. Secondly, degradation due to chemical warfare will not be addressed. Third, local, test, and ferry flights will not be included for simplicity and also because they did not affect results of a previous study (11:44). Finally, integral crews will be maintained to avoid a complex scheduling algorithm on the front end of the model. Integral crews and additional assumptions associated with the input data will be discussed in Chapter II.

Historical Background

Making credible minimum cost estimates of the productivity of the airlift force demands having the minimum number of aircrews per aircraft (aircrew ratio) that still allows the mission to be accomplished.

The primary reason for minimizing aircrew requirements is money. A Government Accounting Office report to Congress illustrates this fact:

A reduction of the aircrew ratio of 3.25:1 to 3:1 crews per aircraft for the C-5, and 4:1 to 3:1 aboard the C-141 would trim AF funding requirements by as much as \$105 million for the airlift forces if only active duty crews were cut and \$66 million if only reserve personnel were cut. (3:4)

Aircrew ratios are used not only in the budgeting process, but also in evaluating wartime requirements, squadron manning, crew welfare, tolerable workloads, and mission effectiveness.

An Air Force-wide conference was held at the Pentagon 18-20 March 1985 to discuss the uses of aircrew ratios, the multitudes of approaches for determining these ratios, and command responsibilities. The conference concluded that the aircrew process is a MAJCOM responsibility. They recommended a detailed analysis of both wartime and peacetime mission taskings as a start. Then, with whatever methodology is appropriate, the commands should justify the aircrew ratios, new or revised, in a Program Decision Package. Once approved, if the validated ratio is to satisfy a wartime need, the data is incorporated into the Wartime Requirements Model which studies a total force engagement. The funded ratios are then used to update peacetime rated requirements, manning levels, and budgets. They are published in AFR 173-13, US Air Force Cost and Planning Factors (4).

In 1967, General Estes, Commander Military Airlift Command, motivated MAC to formally study its aircrew manning for the first time when he stated that he did not want the future C-5's capability to be limited by aircrews (10). It was then necessary to determine the minimum crew force required to maximize the C-5's productivity. Many studies have been completed since that time.

Lockheed Corporation offered to accomplish this study for the yet unreceived C-5 at a cost of 2.5 to 6.5 million dollars. Opting for a cheaper alternative, a joint MAC / System Program Office study was begun in April 1967. The School of Aerospace Medicine (USAFSAM) became consultants on the human factors aspects in May and ultimately were given the entire project in September (10). Among their goals was to optimize the crew manning ratio, crew composition, and crew management.

The first simulation model was completed in 1969 and modified in 1974 to include isochronal (calendar based) maintenance, multiple routes, and 1973 Yom-Kippur War data.

In 1979, The General Accounting Office (GAO) had numerous criticisms. Among those were surging longer than required, unduly restricting flying hours, ignoring attrition, assuming staff duties during wartime, and not modeling transition between phases. The accusation was that "unrealistic information was fed into the model" (3). Many improvements have been incorporated since that time, but a few deficiencies still exist: transition between peace and surge and between surge and sustained has not been modeled; alert crews have not been utilized; and enroute maintenance has not been modeled. In addition, since the USAFSAM model has been revised so many times, the documentation is incomplete in some cases and voluminous in others. In fact, in June 1985, Studies and Analysis was unsuccessful in attempts to

fully understand and use the USAFSAM model in-house at the Pentagon (24).

Other studies have been completed. The "TAC Flier" model (TAC's counterpart in crew ratio determination) is under revision at this time. However, because of the divergence of missions between TAC and MAC, it is unusable. For instance, in TAC all sorties return to the launching base, and in MAC the aircraft may not return for two to three weeks. The obvious place to look for a workable model is the commercial airlines whose missions are somewhat akin to MAC's. Unfortunately, the airlines contacted were reluctant to divulge proprietary information.

Analytic studies have been accomplished. Robert L. Stowell published an analytic method in 1980 that depends heavily on simulation output (23). The Center for Cybernetic Studies at the University of Texas attacked the mission planning and scheduling problems. Their algorithm starts with a solution to a linear programming problem of scheduling aircraft and then uses Bender's decomposition technique for the assignment of crews to the flight legs (1:7,13). They also showed the relationship between minimizing total completion time and its dual, a transshipment problem, that can be solved as a network (1:9). In 1966, a MAC crew ratio (MACRO) study group was formed to determine the appropriate aircrew ratios for MAC airlift. The end result was a set of regression equations with two

independent variables each depending on the known quantities. The equations are still in use today for aircrew activity planning (13:44). Another result of this study group was Eq (1) for a quick guess crew ratio. It is still in use at HQ MAC plans.

$$CR = \frac{(45 \text{ days} \times \text{surge PUR}) + (45 \text{ days} \times \text{sustained PUR})}{(\text{avg. 90 day flying time}) \times (\text{percent available})} \quad (1)$$

The results of the Cybernetic study were accurate for small problems, and the MACRO equation gives a lower bound on the crew ratio. However, practical airlift problems have given rise to a "mixed integer programming problem with about 32000 constraints, 35000 linear variables (including logicals) and 10000 zero-one variables" (1:6). Because of the dynamic nature of the airlift system and the extremely large dimensions of an analytic model, simulation will be the general technique applied in this study.

Overview

The remainder of this thesis consists of four chapters. Chapter II describes the simulation model, its input data, and inherent assumptions. Chapter III contains the methodology. The experimental design, major factors, factor screening, measures of effectiveness, scenarios, and verification/validation are discussed. Chapter IV describes the results. Included are the statistical results of Analysis of Variance, regression results, and sensitivity analysis.

The final chapter, Chapter V, discusses the conclusions reached during the course of this research and recommendations for future analysis.

II. Model

The purpose of this chapter is to explain how aircraft and aircrews are modeled as they flow through the airlift system. The first section of the chapter briefly describes the SLAM simulation language. The second section gives a narrative description of the model and describes the interaction of the FORTRAN and SLAM network sections of the model. The third section discusses the input data, its sources, and the assumptions made when applying it. The final section then describes the output of the model.

SLAM Background

Rather than presenting a detailed description of SLAM, this section provides a simplified description of the language that is necessary for understanding the development of the crew ratio model. Further detail on SLAM can be found in Pritsker (20) and Banks and Carson (2).

SLAM is a special purpose FORTRAN-based simulation language which allows an event-scheduling and/or a process-interaction orientation toward modeling (2:99). The type of orientation used depends on the level of complexity needed and the extent to which the model will have to be embellished for future uses.

The event scheduling orientation concentrates on events and how they affect the states of the system. It uses a FORTRAN model to schedule events to occur at predetermined times.

The process-interaction approach concentrates on entities and the sequence of events and activities they undergo as they flow through the system. The processes are represented by the nodes and branches of a network.

The interaction of the FORTRAN and network models allows events to alter the flow of entities in the network and also allows entities in the network to initiate events in the FORTRAN model.

Narrative Description

The model developed in this research is a discrete-event network simulation employing both orientations (event-scheduling and process-interaction) to model a portion of the MAC airlift system. Fig. 2.1 shows the basic flow through the network as well as how the crews, missions, and aircraft are integrated.

The SLAM network consists of eight major sections: initialization, mission generation, crew rest, preflight, mission sortie, enroute stop, postmission, and scheduled maintenance. In addition, some events are more conveniently handled with FORTRAN interaction. Examples of these events include contingency phase changes from peace to surge and surge to sustained, alert crew regeneration, and mission cancellation. Appendix A shows a more detailed flow of crews and missions (entities) and aircraft (resources) through the system. Appendices B and C contain the SLAM and FORTRAN code respectively. Each subsection is described

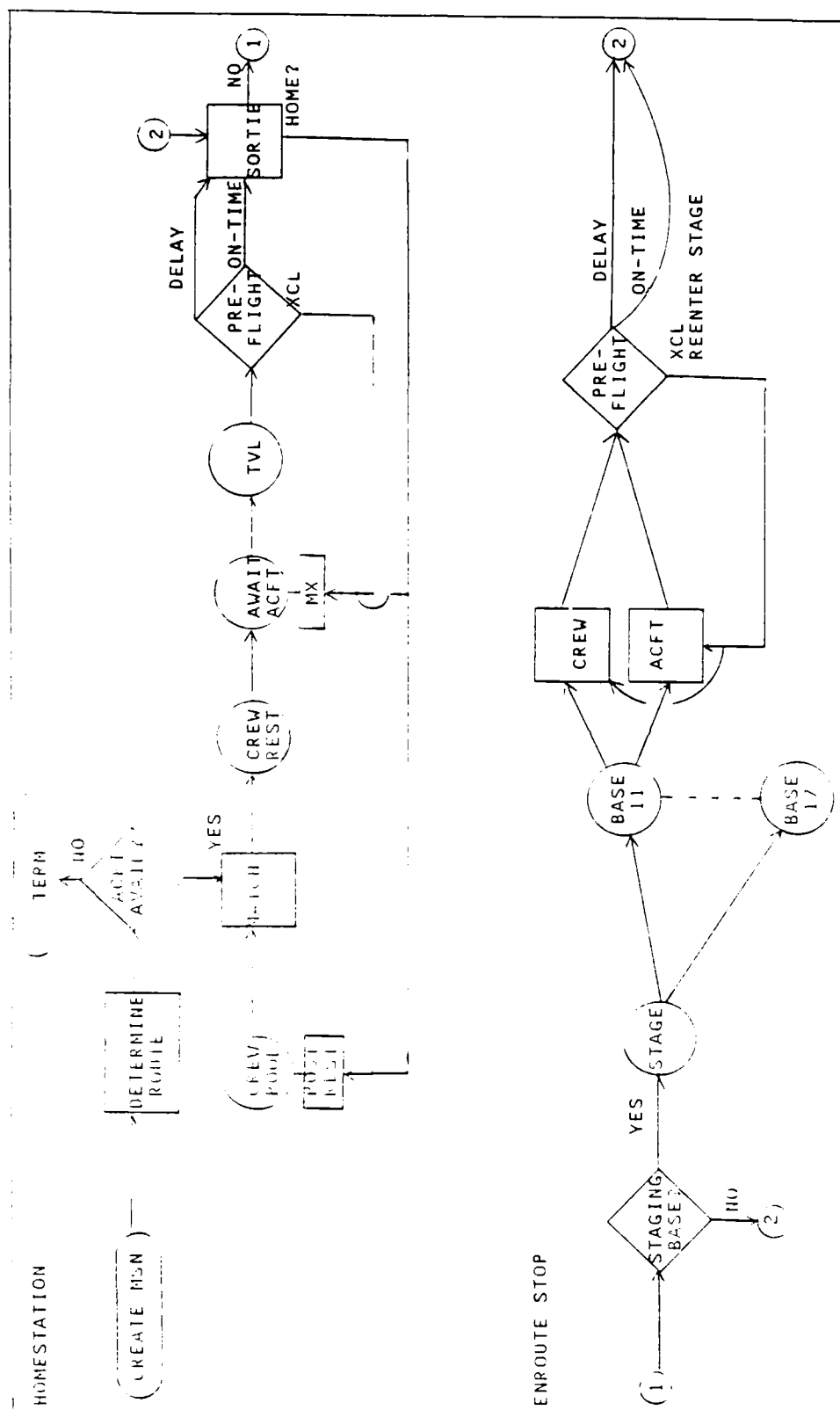


Fig. 2.1. Model Flow

below followed by a description of the input data and inherent assumptions. The time increment in the model is hours.

SLAM Network.

Initialization. In the initialization section of the SLAM model, the user defines:

1. Staging policy
2. 30/90 day flying time limits
3. Launch reliabilities
4. Percent of assigned crews that are mission capable and available
5. Ratio of crews to aircraft
6. Number of crews initially available
7. Peacetime maximum ramp time before reentering crew rest
8. Length of time within which a crew may be alerted without requiring additional crew rest
9. Number of hours after which a scheduled mission is cancelled if no crew or aircraft is available

These parameters will be described in detail later in this chapter.

Scenario data is input through an external file, "ROUTE". This file encompasses routing, scheduled flight times, scheduled ground times, whether a base is a staging location, and target utilization rates for peace, surge, and sustained operations. Appendix D shows the format for this data file.

After the scenario is established, the aircraft are created, the crews are created, and identification numbers are assigned to each crew. One crew is put in BRAVO alert status (i.e. on telephone alert and capable of launch in three hours). Incidentally, MAC's utilization of BRAVO

crews is uncertain for contingency operations. Quite possibly all crews will be on telephone alert, but using one crew here is sufficient to model the effect desired.

Accrued flying time is then tested and if a crew is within twenty hours of its monthly or quarterly flying time limits, it is delayed twelve hours and placed at the end of the crew pool. If a crew has exceeded either of these two limits, it is delayed twenty-four hours. These rules do not force low time crews to be scheduled first, but it does preempt high time crews.

Mission Generation. Missions are generated at a rate commensurate with the target utilization rate. For example, if the peacetime target rate is 3.5 and the expected flying time for a mission is 19.1672 hours (from the scenario), a mission would be generated every 4.381 hours as shown in Eq (2).

$$\begin{aligned} \frac{3150 \text{ hrs.}}{\text{mo.}} & \div \frac{19.1672 \text{ hrs.}}{\text{msn.}} = 164.343 \text{ msns./mo.} \\ \frac{164.343 \text{ msns.}}{720 \text{ hrs.}} & = \frac{1 \text{ msn.}}{X \text{ hrs.}} \quad (2) \\ X & = 4.381 \text{ hrs.} \end{aligned}$$

These missions are assigned a mission number and are either passed to a mission pool to wait for a crew or cancelled if there are no aircraft on station or projected inbound.

Crew Rest. When a crew and mission are matched, the crew enters predeparture crew rest and waits for an aircraft. Predeparture crew rest is normally twenty-four

hours waivable to twelve. Since schedulers usually have enough notice to put the crew into crew rest earlier, this model will observe only the inviolate twelve hours. The crew is allowed one hour travel time to the base once the crew, aircraft, and mission are matched together.

Preflight. Preflight (ground) time (normally 2.3 hours) is distributed as depicted in TABLE 2.2 and will be discussed later in this chapter. Probabilities of an on-time launch, delayed launch or rescheduled launch (launch reliabilities) are as specified in the initialization section of the model.

Mission Sortie. During the flight portion, the next leg is looked at to ensure duty day limits will not be broken. If the basic sixteen hour duty day would be exceeded, the crew reenters crew rest and subroutine 'Cancel' is initiated (the FORTRAN subroutines will be defined later). The actual flying time is distributed with a triangular distribution from one-half hour early to one hour late. This variation will account for wind changes, traffic control delays, diversions, etc. At the end of each sortie, flying time is updated and the average achieved utilization rate over that phase of the conflict is computed.

Enroute Stops. At an enroute stop, unless it is a scheduled staging location, a throughflight is accomplished taking approximately 2.3 hours, and the flying phase is entered again. If the mission is at a staging location,

duty day and interarrival statistics are compiled and the mission is routed to the appropriate stage base subprogram. An identical (except for statement labels and queue numbers) subprogram exists for each enroute stop in the model. The aircraft and mission are assigned to the next available crew, and the previous crew enters crew rest and subsequently enters the available pool. If a crew exceeds its 30/90 day flying time limits, that crew is transported (dead-headed) home (after a minimum crew rest) taking approximately twenty-four hours. Enroute station preflight times and launch reliabilities are obtained in a similar manner as those at home station.

Postmission. If the next station is the home base, statistics are collected on mission lengths, time away from station, average work month, and average monthly flying hours. Unscheduled maintenance is performed (normally distributed with a mean of six hours) and if scheduled maintenance is not required, the aircraft is freed for the next mission.

Scheduled Maintenance. Scheduled maintenance for the C-17 will include two days down every sixty days for a homestation check, ten days down every eighteen months for refurbishment, and thirty days down every thirty-six months for an Analytic Condition Inspection (A.C.I.) (21:3). MAC has stated that A.C.I. and refurbishment will not be accomplished during surge.

The aircraft are removed for scheduled maintenance only at home station at the completion of a mission. The frequency at which an aircraft is removed is dependent on the number of aircraft:

Homestation: $60 \text{ days} \times 24 \text{ hrs/NACFT}$

Refurbishment: $547.92 \text{ hrs (18 mos)} \times 24 \text{ hrs/NACFT}$

A.C.I.: $1095.84 \text{ hrs (36 mos)} \times 24 \text{ hrs/NACFT}$

FORTRAN Events.

Bravo. Anytime a mission is being rescheduled at home station, a check is made to see if a BRAVO alert crew is available. If so, the new crew is matched with the mission and 'Upbrav' is called to regenerate the alert crew.

Cancel. Every hour the mission pool is checked. If a mission has been scheduled for more than twelve hours (specified by user) and is still lacking a crew or aircraft, that mission is removed from the pool and cancelled.

Midup. Every twenty-four hours, the index is incremented for accumulating flying time. Since the model is concerned with quarterly flying time, the index resets to one after ninety-one. Additionally, if no flying time is flown in a particular day, the previous day's total is carried forward.

Mission. When a mission is generated, it is assigned a mission number based on its frequency of usage during the particular phase of conflict.

Next. 'Next' determines a new sortie's destination, scheduled air time, scheduled ground time, and whether the next stop is a staging location.

Stagecr. At the beginning of each phase (peace, surge, and sustained), stage crews are either positioned to or removed from staging locations. These crews are used to pick up an aircraft and mission when they transit that base allowing the previous crew to enter crew rest. The total number at each base is based on the number of missions projected to transit that location in a month. It is equal to:

$$\sum \left(\text{Route freq.} \times \frac{\text{hrs per mo}}{\text{msn exp. fly time}} \div \text{stage factor} \right) \quad (3)$$

Once again, MAC does not have a definite staging "policy" (17). This technique (based on mission transits) was used in the USAFSAM model and appears adequate.

Surge. As surge is entered, missions are generated at a higher rate and the remainder of the reserve complement is added. MAC assumes that a full reserve complement (crew ratio equal to that of active duty) will be available during surge and sustained operations whereas only half is available during peacetime. (24) In addition, scheduled maintenance is cancelled and crew work rules are changed. Specifically, maximum ramp times and alert windows are extended to twelve hours, and post mission crew rest is reduced to twelve hours.

Sustain. After forty-five days of surge, normal work rules and scheduled maintenance are resumed. Mission frequency is also updated based on the utilization rates desired for the next forty-five days.

Upbrav. Every forty-eight hours, or when a BRAVO crew is utilized, a new BRAVO crew must be generated. If no crews are available, the next available crew assumes the duty after twelve hours of crew rest.

Upfltm. At the end of each duty day, monthly and quarterly flying times are updated.

Warmup. The simulation is assumed to reach steady-state after 600 hours. At that time, flying time, duty time, and time away from station are reinitiated to zero to force the statistics to apply only to the current phase of conflict. Warmup is discussed further in Chapter III.

Window. Every hour, all crew pools (at home and enroute) are checked for the length of time they have been legal for alert. If this user specified limit is exceeded, the crew reenters crew rest and the mission goes to the next available crew.

Input Data and Assumptions

Previous models of this type have become so complicated that they are virtually unintelligible. To help reduce the complexity of this model, many assumptions have been made at the outset. Factors shown previously to be of little importance are omitted or aggregated. Historical C-141

experience was used with adjustments for a C-17 contingency environment. Note, however, that the computer code can be modified if future analysis suggests revision. In other words, initiating the model with different input values is easy in the initiation section of the SLAM portion, whereas a change in logic would require computer code revision.

A major assumption has to do with diversions. All missions will start and terminate at their home bases. Diversions and their subsequent rescheduling are difficult to plan for and model accurately. Their effect overall (except possibly some inefficiency) should average out as the cargo has the same ultimate destination.

Another parameter, attrition, will not be modeled. Traditionally, it has not been modeled in MAC studies because it is assumed that it will only affect Backup Inventory Aircraft (BIA) and not impact the Primary Assigned Aircraft (PAA) (22). In addition, losing a PAA aircraft improves the crew ratio unless replaced with a BIA. The system would then have more aircrews per aircraft to accomplish the same mission. Thus, the assumption is a conservative one.

Augmented crews (additional crewmembers added to a crew for air refueling or to lengthen the crew duty day) will not be considered. This is necessary in order to maintain an integral crew as an entity. Integral crews are not used in MAC, but treating them that way allows for easier

bookkeeping and a way to aggregate many schedule related parameters such as illnesses and emergency leave (incorporated in percent of crews available). This assumption should have little effect as augmented crews put an additional resource requirement on schedulers, and this extra burden would be offset with the added scheduling flexibility of non-integral crews. It is also a reasonable assumption since crews are generally not split up once they leave homestation, and quite often crews are rescheduled together during heavy flying activity.

In this model, peacetime is treated the same as wartime in many respects. MACR 28-2 states that no formal training will be conducted during contingencies (7:12), and ordinary leave will be suspended at least through the third month of a general war (7:33). Obviously, during peacetime these two factors play a role but the benefits gained by adding the scheduling algorithm alluded to early in this chapter are not worth the costs of the additional run time. Also, thus far at the Air Staff, peacetime capability is not as important as the transition from peacetime to surge. The important thing is that the drivers of MAC's capability (surge and sustained) are not affected by the peacetime simplification.

HQ MAC and MAC Numbered Air Forces have waiver authority over many aircrew restrictions such as length of crew rest, flying time limits, duty day limits, etc. (6:4-1).

This model will be capable of addressing these waivers, but the only ones that will specifically be addressed in the analyses are the 30 and 90 day flying time limits.

Engine running on/offloads (ERO's) will not be considered directly. Their reduced ground times would definitely impact the model output, but a definite MAC policy does not exist for their utilization. Scheduled ground time will be varied in the model which will measure the effect of the reduced ground time.

All missions are assumed to have the same priority. In peacetime, this is definitely not the case. For instance, nuclear airlift missions and exercise missions have priority over static displays. But during wartime, it is realistic to assume approximately equal priority for all missions.

Input data carries with it many of these assumptions. It falls into two categories, crew related and system related. Some are stochastic, and others are set by policy. TABLES 2.1 and 2.2 below summarize the data and its origin (excluding the experimental factors which will be covered in detail in the next chapter). Lack of a source indicates that the value is based on personal experience.

Output

Appendix E contains excerpts of the output generated by this simulation. Four measures of effectiveness will be discussed in the next chapter: achieved aircraft utilization, average work month, average monthly flying hours, and

TABLE 2.1

Crew Related Characteristics

<u>Parameter</u>	<u>Value</u>	<u>Source</u>
Alert Window	Peace: 6 hrs. Surge & sustained: 12 hrs.	MACR 55-1
Predeparture Rest	12 hrs. inviolate	MACR 55-141
Enroute Rest	UNFRM(13,14) 12 hrs. min.----- + 1 hr. tvl + post msn duties	
Post mission Rest	12 hrs. if gone < 36 Time gone ÷ 3 < 72	MACR 55-141
Crew Duty Day	16 hrs.	MACR 55-141
Max Ramp (before crew rest)	Peace: 6 hrs. (4 by reg. + 2 ground time) Surge & sustained: 12 hrs.	MACR 55-1
Deadhead Time (back home)	RNORM(24,3)	-----

TABLE 2.2

System Related Characteristics

<u>Parameter</u>	<u>Value</u>	<u>Source</u>
Sched. Maintenance	H.S.C.: RNORM(48,1) Refurb: RNORM(240,5) A.C.I.: RNORM(720,10)	C-17 Ute Rate Staff Study
Max. Resched. Delay	12 hrs.	USAF/SAGM
Ground Time (on-time)	UNFRM(2.0,2.3)	HQMAC/LG
Ground Time (delay)	UNFRM(2.3,Max ramp)	(29 mos C-141)
Ground Time (2nd crew)	EXPON(3.3) incl. travel	
Enroute Gnd (on-time)	UNFRM(Sched-.5,Sched+.2)	
Enroute Gnd (delay)	UNFRM(Sched+.2,Max ramp)	
Ground Time (resched)	TRIAG(Max ramp-2,Max ramp)	
MX After Cancel	UNFRM(3,12)	-----
Number Aircraft	30	USAF/SA

time away from station. In table and graphical format, these measures are compiled every five days for the peacetime, surge, and sustained phases. This makes trend analysis very easy.

Besides the primary MOE's, statistics are gathered on the number of crews at home station, number of mission capable aircraft, duty days, mission lengths, overall flying times, cancellations, and enroute station interarrival times. In addition, statistics are generated for every queue (file), activity, and type of resource in the model.

Not all of these statistics are used in this analysis, but the advantage of having them all printed out is their availability for any "after the fact" analysis that may be requested by the users. They also serve a valuable purpose in model validation (discussed in Chapter III).

III. Methodology

This chapter discusses the tactics and strategy followed in running the simulation model. The objective is to answer the last of the research questions: What input parameters need to be considered in determining aircrew ratios? In answering this question the model validity will be established as well as its best use. Included in the chapter is a discussion of the warmup period, the experimental factors, the primary measures of effectiveness, model validation/verification, and the experimental design.

Warmup and Phase Transition

Pilot simulation runs indicated that it took approximately six hundred hours for the aircrew distribution, utilization rates, etc. to stabilize. Therefore, a warmup period of six hundred hours is added to the front end of the simulation to reach steady state.

Surge and sustained operations never reach steady state, which is typical of short real world conflicts. This transition period is a very complex issue.

The inherent variables pose questions such as: does warning time permit gradual buildup or require a prompt response; are we in a normal peacetime operation, standing down in preparation, or operating at a higher than normal level; are reserves mobilized at once or only after the situation worsens, and how many days does it take to make the decision to mobilize? (Response to GOA) (17)

The model developed in this research balances these issues. Stage crews are positioned instantaneously simulating

strategic warning and time to build up. Reserves are mobilized at the beginning of surge; and at the same time, activity rate is increased.

Experimental Factors

Anyone with knowledge of MAC's worldwide airlift system could list hundreds of factors that could influence the number of crews required to accomplish the mission. Reducing this list of factors to the most significant ones results in a simpler model. A simpler model is less expensive and allows for a more thorough analysis of the most significant factors. It requires fewer inputs, is easier to document and interpret, and facilitates transfer from one computer to another or incorporation into a larger system.

Based primarily on personal experience, eight factors are investigated in the experimental design. Other factors in the model are assumed either to be less subject to change or are such that changes in them would not significantly alter the final results. The eight factors are discussed below and summarized in TABLE 3.1.

a) Staging Policy. Staging policy is based upon the number of staging transits of a base. A MAC policy does not exist for staging its aircrews, however the USAFSAM study indicated that staging policy was a significant factor with the optimal near 45 (i.e., stage a crew for every 45 transits in a month).

TABLE 3.1
Experimental Factors

<u>Factor</u>	<u>Range</u>
a) Staging Policy	30 to 60
b) 30/90 Day Fly Limits	125/330 to 150/450
c) Target Ute. Rates (peace/surge/sustained)	3.5/15.1/13.4 to 4.5/16.1/14.4
d) Percent of Crews Available	.80 to .90
e) Crew Ratio	4.0 to 5.0
f) Launch Reliability (on-time/delay/reschedule)	.948/.044/.008 to .955/.044/.001
g) Ground Time	2.1 to 2.3
h) Scenario	NATO to S.W. Asia

b) Monthly and Quarterly Flying Time Limits. During periods of heavy flying, the monthly and quarterly flying time limits are often scheduling limitations. USAF/SA is presently studying a proposed change to AFR 60-1, changing the present limits of 125/330 to 150/450 hours per month and quarter respectively (24).

c) Target Aircraft Utilization Rates. L.K. McSemann, II, Acting Assistant Secretary of the Air Force for Research, Development, and Logistics, has directed the Air Force to use the design utilization rates of 13.9 hours per day sustained and 15.6 hours per day surge for all systems comparisons (21:2). This study will vary these numbers by 0.5 hours on either side. The 4.0 peacetime rate was suggested by Studies and Analysis (24).

d) Percent of Crews Available. HQ MAC uses a .90 crew mission capable rate (per manpower directives) for most studies (22). Considering essential wartime additional duties and crew management inefficiencies, this value will be ranged between .80 and .90. It will take into account crewmembers in pipeline training, sick, on emergency leave, or committed to other duties.

e) Crew Ratio. The ratio of assigned crews to each aircraft will range from 4.0 to 5.0. 4.0 is the current ratio for C-141 crews. 5.0 is the proposed C-17 ratio needed to fill our airlift shortfall. Realistically, the required ratio will fall somewhere in-between.

f) Launch Reliability. Analyzing two years of C-141 data gives an average on-time (0.2 hrs. before scheduled to 0.3 hrs. after) departure reliability of 0.948 at home and 0.955 enroute, with the probabilities of having to be re-scheduled equal to 0.008 and 0.001 respectively (12). These figures include local training flights which this model ignores. Also, even though maintenance reliability for the C-17 should be greater, supply, refueling, passenger processing, etc. will hold the rates down. It should be noted that a pilot run showed significance in this small range.

g) Ground Time. Scheduled ground time for C-141's and C-17's is 2.3 hours. Frequently, this time can be shortened in high threat areas with engine running on/offloads, etc. This screening will consider an average between 2.1 and 2.3.

h) Scenarios. Scenarios were suggested by USAF/SAGM. Pilot runs of multiple home base scenarios do not warrant using the expanded model for analysis. For the user's interest, Appendices F and G contain a workable multiple home base model. Asterisks indicate differences from the single base model. The screening will use two scenarios, one S.W. Asia and one NATO, each with a single home base (See Appendix H).

Measures of Effectiveness

Since the ratio of crews to aircraft is an input to the simulation, it would be nice to have the output portray a crew related statistic, a mission related statistic, and an aircraft related statistic. Achieved utilization rates (AUR) of aircraft, average flying hours per month, and mission cancellations are all useful, quantifiable measures.

Target utilization rates (TUR) are inputs to the model; so instead of analyzing just AUR, it must be analyzed with respect to the programmed target rates. Utilization rates will be measured at the end of each phase and will be the average of only that phase.

Average flying hours per month will also be measured for each phase. An alternative measure here could be the work hours per month since it is a common manpower measure.

The number of missions cancelled due to no aircraft or crew, to be consistent, will also be measured at the end of each phase.

Model Verification and Validation

Credibility is of utmost importance for a model to be considered for implementation. If the model's assumptions and logic are valid and the results have been verified, this credibility is guaranteed.

Validation will be somewhat difficult since the C-17 is not yet operational and wartime scenarios are not often tested operationally. However, the trends discovered during the analysis closely resemble the results of the USAFSAM study completed earlier this summer. For example, the peacetime achieved utilization rate (steady state) was within .2 hours of their results. The USAFSAM model measured steady state utilization rates between 11 and 15.5 hours during the surge phase and between 11 and 14 hours during the sustained phase. For the same target rates, this study found average rates of approximately 10 and 9 hours surge and sustained respectively. The lower rates are due to measuring an overall average for the phase rather than a steady state average, sacrificing some statistical robustness. An overall average seems more appropriate as realworld mission flow change during a phase and steady state is seldom reached. The lack of disparities between the models, in a sense, validates both models. In addition, Maj Wayne Stanberry, HQ MAC/XPSR, who has extensive experience both in SLAM simulations and modeling the MAC airlift system, critically reviewed the model, its assumptions, and results for face validity.

The logic has been verified primarily through periodic flow charting, concurrent debugging during the programming, pilot runs, and a SLAM TRACE option tracing missions, crews, and aircraft through the system. Assessing the reasonableness of output also helps verify the model. Partially mission capable (PMC) rate for the C-17 is guaranteed to be at least 82.5% (21). PMC in this simulation refers to any aircraft not in a preflight status or scheduled maintenance. The mean PMC rate through surge for the 64 initial screening runs was 78.223%. If the PMC aircraft in a preflight status were added, the numbers would be very close. Finally, consistency of the output was examined both over the ranges of interest and at extreme values to stress the system and check for reasonableness.

Design

The goal in the design phase is to investigate the relationships between the independent variables (factors) and the response (simulation output), determining, if possible, which factors exert the greatest effect on the response, and the extent of interaction between or among the factors. In the screening experiments, only two levels of each factor are investigated. These levels should be "far enough apart to measure anticipated effects, but not so far as to cause nonlinearities in the functional relationship to distort or mask significant effects (15:348)". This analysis will use the extreme values of the factors listed in TABLE 3.1.

TABLE 3.2

1/4 Replication of 8 Factors (9:22)

(1)	cdgh	abcg	abdh	bdefh	bcefg	acdefgh	aef
abcfgh	abdf	fh	cdfg	acdeg	aeh	bde	bcegh
bcdeg	beh	ade	acegh	cfgh	df	abfh	abcdfg
adefh	acefg	bcdefgh	bef	ab	abcdgh	cg	dh
efgh	cdef	abcefh	abdefg	bdg	bch	acd	agh
abce	abdegh	eg	cdeh	acdfh	afg	bdfgh	bcf
bcdfh	bfg	adfg	acf	ce	degh	abeg	abcdeh
adg	ach	bcd	bgh	abefgh	abcdef	cefh	defg

It is difficult to account for aliases in a Resolution III or IV (some or all two factor interactions confounded) design because interactions that can be ignored are not obvious. Initial screening, therefore, will assume three factor and higher interactions to be negligible and will use a 2^{8-2} or 1/4 replication of a 2^8 factorial to analyze all main factor effects and all two way interactions. This reduces the number of simulation runs from 256 for a full factorial to 64 with the fractional and also gives 27 degrees of freedom for error. The number of runs is reasonable since each run uses 2.5 minutes of C.P.U. time. The result is a Resolution V design in which no main effect or two factor interaction is aliased with any other main effect or two factor interaction.

The design chosen for screening is shown in TABLE 3.2. Small letters indicate a particular factor is at its high level. (1) indicates all factors are at their low levels. The defining contrast is $I=ABCEG=ABDFH=CDEFGH$. For further

explanation, refer to Montgomery (14) or any Design of Experiments text.

In the second stage, the results of the initial screening were analyzed and the best set of subsequent runs chosen. It will be shown in the next chapter that two factors are insignificant and can be removed. This makes this fractional factorial design equivalent to a 2^6 full factorial. By adding center points and axial points to the original design, orthogonality and uniform precision (variance) can be maintained. To keep all observations independent in the initial screening, a different set of random number seeds was used for each run. Also for the screening, measures of effectiveness were only evaluated during surge.

IV. Analulus and Results

The goal of this chapter is to give decision makers a tool to use in determining aircrew ratios. Results of the initial screening experiment will be discussed. Then the subsequent runs, setup, and results of the regression analyses will be described. Finally, sensitivity analysis on the major factors will be presented.

Initial Screening Results

Analyses of variance were accomplished for the fractional factorial design using the BMDP2U statistical package. The data and an example input program are included as Appendix I. Analyses for three measures of effectiveness (achieved utilization rate, average work month, and average flying hours) will be discussed separately. The small number of mission cancellations eliminated cancellations from consideration.

At the 99% confidence level, there are three main effects which significantly affect achieved utilization: staging policies, flying time limits, and scenarios. These and the significant two-factor interactions are shown in TABLE 4.1. Target utilization rates, crew ratios, and ground times are not significant at this level. However, since the crew ratio is as much a determinant of the number of crews as the percentage of crews available, it has

TABLE 4.1
Analysis of Variance -- AUR

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MEAN	6230.07312	1	6230.07312	36550.70*
STAGE	2.36165	1	2.36165	13.86*
FLYLMT	2.88767	1	2.88767	16.94*
TUR	.18953	1	.18953	1.11
PERCENT	.00396	1	.00396	.02
CR	.01747	1	.01747	.10
RELIAB	.00010	1	.00010	.00
GND	.08075	1	.08075	.47
LEGS(Scenario)	3.56454	1	3.56454	20.91*
SF	5.53338	1	5.53338	32.46*
ST	.26665	1	.26665	1.56
FT	.54438	1	.54438	3.19
SP	.02561	1	.02561	.15
FP	.04248	1	.04248	.25
TP	.03145	1	.03145	.18
SC	.04274	1	.04274	.25
FC	.00125	1	.00125	.01
TC	.00022	1	.00022	.00
PC	.01041	1	.01041	.06
SR	.04789	1	.04789	.28
FR	.00012	1	.00012	.00
TR	.18293	1	.18293	1.07*
PR	3.97575	1	3.97575	23.32*
CR	.02129	1	.02129	.12
SG	.25184	1	.25184	1.48
FG	.00194	1	.00194	.01
TG	.00101	1	.00101	.01
PG	.35375	1	.35375	2.08
CG	.67867	1	.67867	3.98
RG	.04575	1	.04575	.27*
SL	2.42980	1	2.42980	14.26*
FL	3.54130	1	3.54130	20.78*
TL	.01789	1	.01789	.10
PL	.20469	1	.20469	1.20
CL	.00106	1	.00106	.01
RL	.12956	1	.12956	.76
GL	.18162	1	.18162	1.07
ERROR	4.60216	27	.17045	

*-Significant at 99%

probably been masked by a higher level interaction and will not be omitted.

TABLE 4.2
Analysis of Variance -- AUGWORK

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MEAN	1037637.62919	1	1037637.62919	37508.56*
STAGE	1853.73322	1	1853.73322	67.01*
FLYLMT	525.78509	1	525.78509	19.01
TUR	1.75561	1	1.75561	.06*
PERCENT	3224.82020	1	3224.82020	116.57*
CR	12002.29767	1	12002.29767	433.86
RELIAB	10.93956	1	10.93956	.40
GND	8.41000	1	8.41000	.30*
LEGS(Scenario)	576.72047	1	576.72047	20.85*
SF	929.03049	1	929.03049	33.58
ST	54.39063	1	54.39063	1.97
FT	52.56253	1	52.56253	1.90
SP	20.36263	1	20.36263	.74
FP	32.91892	1	32.91892	1.19
TP	33.55301	1	33.55301	1.21
SC	.71403	1	.71403	.03
FC	38.06890	1	38.06890	1.38
TC	5.88066	1	5.88066	.21
PC	81.22517	1	81.22517	2.94
SR	43.65908	1	43.65908	1.58
FR	4.54755	1	4.54755	.16
TR	29.02516	1	29.02516	1.05*
PR	694.84963	1	694.84963	25.12*
CR	3.03631	1	3.03631	.11
SG	33.06250	1	33.06250	1.20
FG	1.89063	1	1.89063	.07
TG	1.48840	1	1.48840	.05
PG	12.72709	1	12.72709	.46
CG	156.25000	1	156.25000	5.65
RG	32.63263	1	32.63263	1.18*
SL	1165.19811	1	1165.19811	42.12*
FL	569.29954	1	569.29954	20.58
TL	3.25803	1	3.25803	.12
PL	15.86026	1	15.86026	.57
CL	3.36725	1	3.36725	.12
RL	21.97266	1	21.97266	.79
GL	16.56493	1	16.56493	.60
ERROR	746.92862	27	27.66402	

*-Significant at 99%

TABLE 4.3

Analysis of Variance -- AUGFLY

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MEAN	409913.65988	1	409913.65988	33932.31*
STAGE	165.25099	1	165.25099	13.68*
FLYLMT	170.43301	1	170.43301	14.11
TUR	16.66681	1	16.66681	1.38*
PERCENT	1235.69840	1	1235.69840	102.29*
CR	4652.60411	1	4652.60411	385.14
RELIAB	.04410	1	.04410	.00
GND	4.69806	1	4.69806	.39*
LEGS(Scenario)	250.03513	1	250.03513	20.70*
SF	386.51556	1	386.51556	32.00
ST	24.42828	1	24.42828	2.02
FT	31.38806	1	31.38806	2.60
SP	1.85640	1	1.85640	.15
FP	13.56081	1	13.56081	1.12
TP	5.19840	1	5.19840	.43
SC	1.31103	1	1.31103	.11
FC	5.73604	1	5.73604	.47
TC	.61231	1	.61231	.05
PC	43.85752	1	43.85752	3.63
SR	14.47800	1	14.47800	1.20
FR	.19802	1	.19802	.02
TR	6.48975	1	6.48975	.54*
PR	288.40528	1	288.40528	23.87*
CR	.00722	1	.00722	.00
SG	30.49802	1	30.49802	2.52
FG	.97515	1	.97515	.08
TG	.76562	1	.76562	.06
PG	10.85703	1	10.85703	.90
CG	63.56075	1	63.56075	5.26
RG	5.67629	1	5.67629	.47*
SL	171.93766	1	171.93766	14.23*
FL	211.77522	1	211.77522	17.53
TL	2.48062	1	2.48062	.21
PL	12.63800	1	12.63800	1.05
CL	.33931	1	.33931	.03
RL	9.81257	1	9.81257	.81
GL	9.67210	1	9.67210	.80
ERROR	326.16904	27	12.08033	

*-Significant at 99%

At the same confidence level, average work month is significantly affected by five main factors: staging

policies, flying time limits, percent of crews available, crew ratios, and scenarios. These and significant interactions are indicated in TABLE 4.2. Again target utilization rates and ground times are not significant.

Factors and interactions affecting average monthly flying times are exactly the same as those affecting average work month; a somewhat intuitive result. TABLE 4.3 illustrates.

Regression Analyses

The fractional factorial design indicates that six potential independent variables explain achieved utilization rates, average work month, and average flying times. As target utilization rates and ground times are eliminated, all experimental combinations containing them are also eliminated. Thus, the 2^{8-2} fractional factorial becomes a 2^6 full factorial (15:330). Since an objective of this study is to fit second order regression equations to the data, the next logical step is to perform additional runs at other levels in order to estimate the nonlinear relationships.

Subsequent Runs. Myers suggests thirty-six additional runs, twenty-four at center points and twelve at axial points with $\alpha = \pm 2.828$ (18:153). α is the multiplying factor used to set levels for the independent variables used in estimating nonlinear relationships. These are needed, not only to generate results at intermediate levels, but to

TABLE 4.4
Composite Levels

	<u>Low Axial</u>	<u>High Axial</u>	<u>Center</u>
a) Staging policy	3	87	45
b) Fly time limits	102.15/220.32	172.85/559.68	137.5/390
c) Target ute.	4.0/15.6/13.9	4.0/15.6/13.9	4.0/15.6/13.9
d) Percent avail.	.709	.991	.85
e) Crew ratio	3.086	5.914	4.5
f) Launch reliab	.942/.044/.014	.962/.038/0	.952/.044/.004
g) Ground time	2.1	2.1	2.1
h) Scenario	NATO	SWA	NATO, SWA

maintain an approximately orthogonal and uniform precision design. Orthogonality will give enhanced meaning to the regression coefficients in the next section (i.e. uncorrelated estimates), and uniform precision (rotatability) ensures uniform variance in the responses. In addition, the replicated center points allow an evaluation of the appropriateness of the equations (18:153).

The factor levels for these subsequent runs are listed in TABLE 4.4. Five of the six main factors (all except scenario) have quantitative midpoints. To account for the sixth factor, twelve center points will be run for each of the two scenarios. The axial levels can be computed using Eq (4) with $\alpha = 2.828$.

$$e_i = \pm 2.828(.5)d_i + \bar{e}_i \quad (4)$$

where d_i = difference between high and low levels

$\bar{e}_i$ = midpoint between high and low levels

Additionally, levels for the deleted factors (ground times and target utilization rates) must be preset. Since

intuition suggests that target utilization rates should be significant, they were set at an intermediate level. Ground time was set at 2.1 hours arbitrarily.

Regression Results. The regression equations presented in this section will enable a decision maker to give initial capability estimates of the achieved utilization rates, average work months, or average monthly flying times given values for the input values.

A problem with including data from axial input values is the extreme responses (outliers) that sometimes arise, as is the case here. Referring to TABLE 4.4, staging policy and flying time limits are well outside the range of interest. For this reason, those observations will not be included in the regression analyses. Other potential outliers were investigated for accuracy but were not eliminated. The reason axial results were not eliminated completely was to maintain a higher degree of uniform precision and orthogonality. This study did conduct analyses without the axial points for comparison's sake; the results were better in some cases and worse in others (not included).

Stepwise regression analyses were performed with BMDP9R using adjusted squared multiple correlation ($\bar{R}^2$). This method recognizes the tradeoff between additional degrees of freedom and the reduced variance associated with adding another variable. It is analogous to minimizing the residual mean square which enhances the predictive capability

(25:179). Separate regression analyses were performed for each scenario to study differences. Appendix J contains the axial and centerpoint data, an example input program, and output from BMDP9R. Analyses of residual plots, scatter plots, and correlation matrices did not show any marked deviations from the model assumptions. The coefficients in the equations on the following pages (TABLES 4.5-4.7) have been decoded to correspond to real data values as opposed to those coded for design matrix values of -1, 0, and 1 found in the appendix.¹ Separate equations are shown for peace, surge, and sustained because of the changes in target utilization from one phase to another; but, they did come from the same regression model. Interactions, where one factor level is dependent on the level of a second factor, can be represented by a cross product term (i.e. multiplying the level of the first term by that of the second). TABLE 4.8 shows the allowable ranges for the parameters.

¹Design matrix values are obtained from $x_i = 2(e_i - \bar{e}_i)/d_i$, where d_i is the difference between high and low levels and $\bar{e}_i$ is the mean. The coefficients in Appendix J, C_i , are in terms of x_i . To translate: $C_i x_i = C_i 2(1/d_i)(e_i - \bar{e}_i) = C_i (2/d_i)e_i - C_i (2/d_i)\bar{e}_i$. $C_i' = C_i (2/d_i)$ and $\beta_0 = \beta_0^i - \sum C_i' (2/d_i)\bar{e}_i$.

TABLE 4.5

Regression Results -- Average Work Month

Peacetime AVGWORK (SWA) = 258.73389-.54325(STAGE)-29.4086(CR) + .4679(FLYLMT)-139.162(PERCENT)+140.5539(PERCENT*RELIAB) + .4066667(CR²)-1.8291225(TUR²)		
Peacetime AVGWORK (NATO) = 377.80656-.0743333(STAGE)-28.1394(CR) -151.7312(PERCENT)+4.5602(PERCENT²)+.3387133(CR²)-.32073(TUR²)		
Surge AVGWORK (SWA) = 347.28515-.54325(STAGE)-29.4086(CR)+.4679(FLYLMT) -139.162(PERCENT)+140.5539(PERCENT*RELIAB)+.406667(CR²)-.4890059(TUR²)		
Surge AVGWORK (NATO) = 392.43066-.0743333(STAGE)-28.1394(CR) -151.7312(PERCENT)+4.5602(PERCENT²)+.3387133(CR²)-.0822487(TUR²)		
Sustained AVGWORK (SWA) = 330.84145-.54325(STAGE)-29.4086(CR) + .4679(FLYLMT)-139.162(PERCENT)+140.5539(PERCENT*RELIAB) + .4066667(CR²)-.3267662(TUR²)		
Sustained AVGWORK (NATO) = 390.25194-.0743333(STAGE)-28.1394(CR) -151.7312(PERCENT)+4.5602(PERCENT²)+.3387133(CR²)-.0822487(TUR²)		
<u>Statistics</u>	<u>SWA</u>	<u>NATO</u>
Squared Multiple Correlation	.92666	.98776
Multiple Correlation	.96267	.99389
Adjusted Squared Mult. Corr.	.91873	.98538
Residual Mean Square	15.401371	1.205105
Standard Error of Est.	5.949922	1.097726
F-Statistic	78.11	417.70
Numerator Degrees of Freedom	7	8
Denominator Degrees of Freedom	42	41
Significance (Tail Prob.)	.0000	.0000

TABLE 4.6

Regression Results -- Average Fly Time

Peacetime AVFLTM (SWA) = 161.94887 - .016796 (STAGE) - 18.54672 (CR) + .2760752 (FLYLMT) - 84.816 (PERCENT) + 90.509496 (PERCENT * RELIAB) + .2452822 (CR²) - 1.58007 (TUR²)		
Peacetime AVFLTM (NATO) = 109.08640 - 17.69142 (CR) - 97.1856 (PERCENT) + 111.346 (RELIAB) + 2.5706275 (PERCENT²) + .2042978 (CR²) - .0009705 (TUR²)		
Surge AVFLTM (SWA) = 235.07206 - .016796 (STAGE) - 18.54672 (CR) + .2760752 (FLYLMT) - 84.816 (PERCENT) + 90.509496 (PERCENT * RELIAB) + .2452822 (CR²) - 1.4057103 (TUR²)		
Surge AVFLTM (NATO) = 154.45597 - 17.69142 (CR) - 97.1856 (PERCENT) + 111.346 (RELIAB) + 2.5706275 (PERCENT²) + .2042978 (CR²) - .085275 (TUR²)		
Sustained AVFLTM (SWA) = 224.02507 - .016796 (STAGE) - 18.54672 (CR) + .2760752 (FLYLMT) - 84.816 (PERCENT) + 90.509496 (PERCENT * RELIAB) + .2452822 (CR²) - 1.4552095 (TUR²)		
Sustained AVFLTM (NATO) = 182.19709 - 17.69142 (CR) - 97.1856 (PERCENT) + 111.346 (RELIAB) + 2.5706275 (PERCENT²) + .2042978 (CR²) - .1097143 (TUR²)		
<u>Statistics</u>	<u>SWA</u>	<u>NATO</u>
Squared Multiple Correlation	.90767	.99012
Multiple Correlation	.95270	.99505
Adjusted Squared Mult. Corr.	.89224	.98790
Residual Mean Square	16.690107	1.257142
Standard Error of Est.	4.107326	1.119438
F-Statistic	56.96	115.19
Numerator Degrees of Freedom	7	9
Denominator Degrees of Freedom	42	40
Significance (Tail Prob.)	.0000	.0000

TABLE 4.7

Regression Results -- Achieved Utilization Rates

Peacetime AUR (SWA) = 2.310045-.0157651(STAGE)+.0247701(FLY/LMT) (Revised) $+.449596(TUR)+8.007181(PERCENT \times RELIAB) - .1497965(TUR^2)$		
Peacetime AUR (NATO) = 1.2719897-.79809(PERCENT)-.0039662(CR²) $-.9862156(PERCENT \times RELIAB) + 13.353543(RELIAB) - 2.8745414(RELIAB^2)$ $+.0753974(TUR) - .0247263(TUR^2)$		
Surge AUR (SWA) = 4.0174422-.0157651(STAGE)+.0247701(FLY/LMT) (Revised) $+.449596(TUR)+8.007181(PERCENT \times RELIAB) - .0034094(TUR^2)$		
Surge AUR (NATO) = 1.6140239-.79809(PERCENT)-.0039662(CR²) $-.9862156(PERCENT \times RELIAB) + 13.353543(RELIAB) - 2.8745414(RELIAB^2)$ $+.0753974(TUR) - .0037507(TUR^2)$		
Sustained AUR (SWA) = 3.7847176-.0157651(STAGE)+.0247701(FLY/LMT) (Revised) $+.449596(TUR)+8.007181(PERCENT \times RELIAB) - .1471069(TUR^2)$		
Sustained AUR (NATO) = .4176098-.79809(PERCENT)-.0039662(CR²) $-.9862156(PERCENT \times RELIAB) + 13.353543(RELIAB) - 2.8745414(RELIAB^2)$ $+.0753974(TUR) - .0037507(TUR^2)$		
<u>REGRESSIONS</u>	<u>SWA</u>	<u>NATO</u>
Squared Multiple Correlation	.68525	.54700
Multiple Correlation	.80948	.73959
Adjusted Squared Mult. Corr.	.58417	.45560
Residual Mean Square	.064878	.010773
Standard Error of Est.	.254607	.103857
F-Statistic	9.23	6.19
Numerator Degrees of Freedom	7	8
Denominator Degrees of Freedom	34	41
Significance (Tail Prob.)	.0000	.0000

TABLE 4.8
Variable Ranges for Regressions

<u>Variable</u>	<u>Definition</u>	<u>Range</u>
STAGE	1 crew prepositioned for every ?? transits	30 to 60
FLYLMT	30/90 day fly limits	125 [*] / 330 to 150 / 450
PERCENT	Percent of crews avail	.80 to .90
RELIAB	Prob. of on-time, delayed or cancelled takeoff	.948 [*] / .044 / .008 to .955 [*] / .044 / .001
TUR	Peace, surge, & sustained target ute rates	3.5/15.1/13.4 to 4.5/16.1/14.4
CR	Crew ratio	4.0 to 5.0
* = Value to enter regression equation with.		

The quadratic response functions for average work month and average flying time for the NATO scenario resulted in a $R^2 > .98$ and a standard error of the estimate ($MSE^{1/2}$) < 1.96 . For the SWA scenario, R^2 was still over .90, but the standard error was larger (5.95 and 4.11 for average work month and flying time respectively). Thus, the predictive capability could be somewhat impaired. See TABLES 4.5 and 4.6.

R^2 for achieved utilization rates were lower (.54700 and .76544 for NATO and SWA scenarios respectively), but the standard error was less than .44 in both cases (See Appendix J). To further investigate the fit of these response functions, the center point replications were used to estimate pure error, thereby splitting the sums of squares into components. The results are shown in Fig. 4.1. This analysis indicates that the NATO regression is adequate and the SWA regression is not. In other words, the SWA numerator

SWA Scenario

$$\bar{y} = 10.25667$$

$$\sum (y_i - \bar{y})^2 = .5364667$$

$$df = 12 - 1 = 11$$

$$MSPE = .0487697$$

$$SSE = 44(.191196) = 8.412624$$

$$SSLF = 8.412624 - .5364667 = 7.8761573 \quad df = 44 - 11 = 33$$

$$MSLF = .2386714$$

$$F = MSLF/MSPE = 4.8938467$$

$$F(.05; 11, 33) = 2.12$$

Reject hypothesis of good fit.

NATO Scenario

$$\bar{y} = 9.7825$$

$$\sum (y_i - \bar{y})^2 = .167467$$

$$df = 12 - 1 = 11$$

$$MSPE = .0152243$$

$$SSE = 41(.010375) = .425375$$

$$SSLF = .425375 - .167467 = .257908 \quad df = 41 - 11 = 30$$

$$MSLF = .0085969$$

$$F = MSLF/MSPE = .564685$$

$$F(.05; 11, 30) = 2.11$$

Cannot reject hypothesis of good fit.

Fig. 4.1. Lack of Fit Analysis for AUR Response Functions

mean square is estimating something which is in excess of σ^2 , the experimental error variance. This could possibly be due to higher order terms that are not included or, more likely, the small number of degrees of freedom for pure error associated with only twelve center point replications.

Further analysis of the residuals for this case (Appendix J) showed three potential outliers, cases 15, 37, and 50. Upon investigation of the simulation output, ten cases

SWA Scenario

$$\bar{Y} = 10.85667$$

$$\sum (Y_i - \bar{Y})^2 = .5364667$$

$$df = 12 - 1 = 11$$

$$MSPE = .0513334$$

$$SSE = 34(.064838) = 2.204492$$

$$SSLF = 2.204492 - .5364667 = 1.6680253 \quad df = 34 - 11 = 23$$

$$MSLF = .0725228$$

$$F = MSLF/MSPE = 1.4870471$$

$$F(.05; 11, 23) = 2.24$$

Cannot reject hypothesis of good fit.

Fig. 4.2. Lack of Fit -- AUR Revised

were found where achieved utilization rate in surge had peaked out earlier in the phase and were on a downward trend when measured; the difference between the peak average and overall average was significant in eight cases. Incidentally, in the NATO scenario, three cases peaked early but only by a very small amount. Deleting these cases (3,13,24,28, 37,41,50, and 62) resulted in an adequate regression. See Fig. 4.4 for the lack of fit analysis and Appendix J for revised residual plots.

Since the equations are scenario dependent, they should only be used to approximate capability, work month, and monthly flying time. Users should keep in mind that the work month and flying time figures do not include duties or training missions at home station.

Confidence Limits. A confidence region is hard to visualize on surfaces such as these but limits could easily be placed on individual input combinations. Boundaries for a Working-Hotelling confidence region over all input combinations, X_h , are indicated in Eq (5).

$$\hat{Y}_h \pm ws(\hat{Y}_h) \quad (5)$$

$$\text{where } w^2 = pF(1-\alpha; p, n-p) \quad (19:244)$$

The standard error of the predicted value, $s(\hat{Y}_h)$, is available from BMDP for combinations in the experimental design. Unfortunately, the interval obtained is only valid at that particular input combination. For example, if one were interested in an estimate of achieved utilization rate for a SWA scenario at input values matching Case 1 where all eight variables are at their high level, $s(Y_h) = .1065$, the number of parameters (p) = 8, and $F(.95; 8, 34) = 2.23$. It follows that:

$$w^2 = 8(2.23)$$

$$\begin{aligned} \hat{Y}_h + ws(\hat{Y}_h) &= 10.9670 \pm 4.22374(.1065) \\ &= 10.9670 \pm .4498 \\ &= (10.517, 11.4168) \text{ with 95\% confidence} \end{aligned}$$

One can readily see here that in spite of the relatively low R^2 , the predictive capability is acceptable.

Sensitivity Analysis

Analysts at HQ MAC and Studies and Analysis are interested in the effect of changing one main factor. The coefficients of the regression equations approximate a unit change in the input parameters, assuming a high degree of orthogonality has been maintained. Most decision makers, however, would prefer a graphical analysis. This section will present graphical comparisons holding all variables constant except one. The variables varied are crew ratio, staging policy, target utilization rates, and flying time limits. The effect of these changes on achieved utilization rates, average work month, average monthly flying times, and time away from station for the NATO scenario will be shown. Appendix K shows the results of three replications for each factor. The variables held constant will take on the center point values from TABLE 4.4.

Crew Ratio Sensitivity. The crew ratio was given values 4.0, 4.2, 4.4, 4.6, 4.8, and 5.0. The impact of these changes is shown in Figs. 4.3-4.7. There seems to be no AUR benefit in increasing the crew ratio to 5.0 as it peaks at 4.8. 4.8 also results in the least amount of time away from home. Another factor in the system is apparently restraining increased benefit. There is an anomaly in the results for a crew ratio of 4.0 that is partially explainable. The crews at homestation were depleted quite early and the number of cancellations due to either no aircraft or

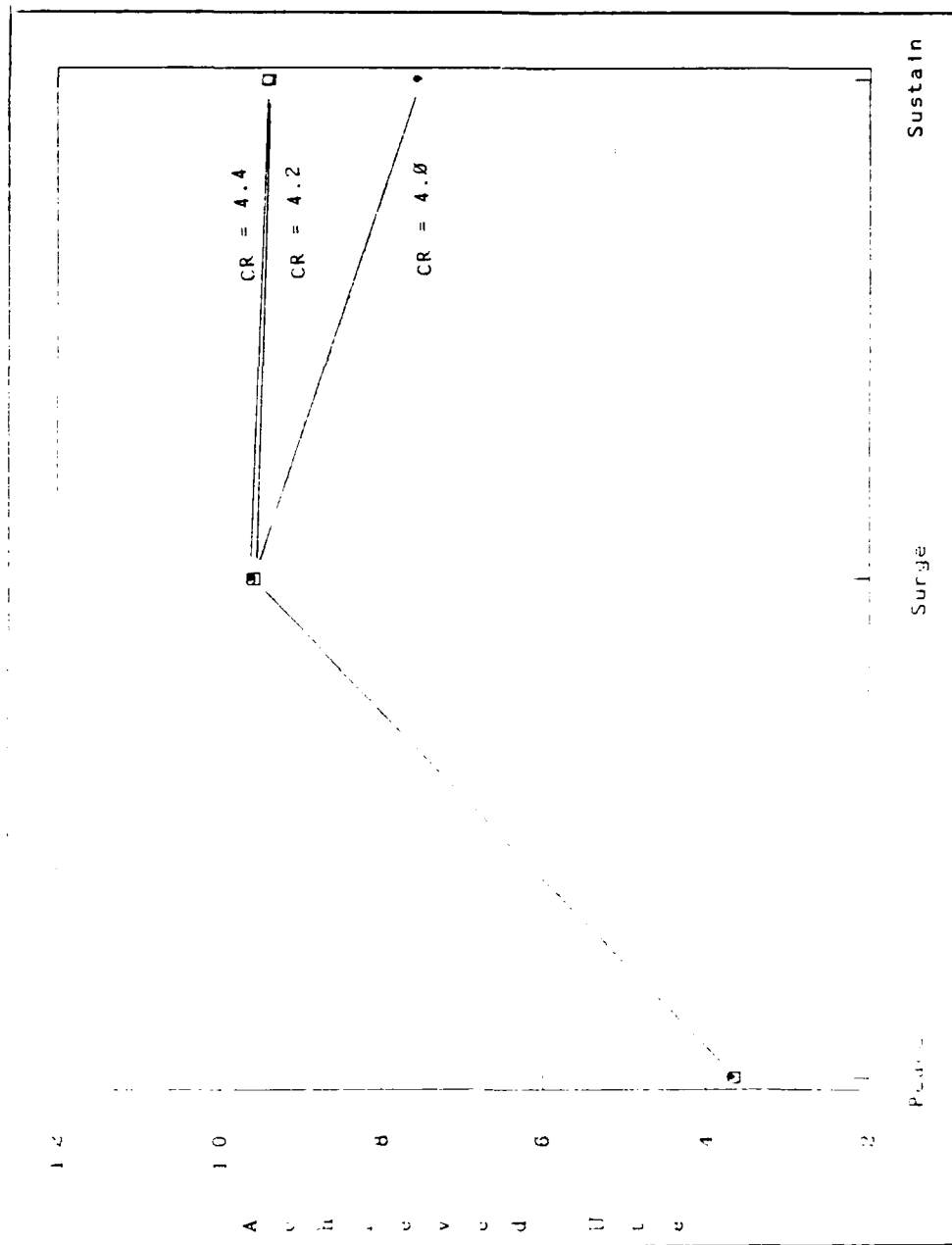


Fig. 4.2. Effect of CR(4.0, 4.2, 4.4) on AUR (WATO)

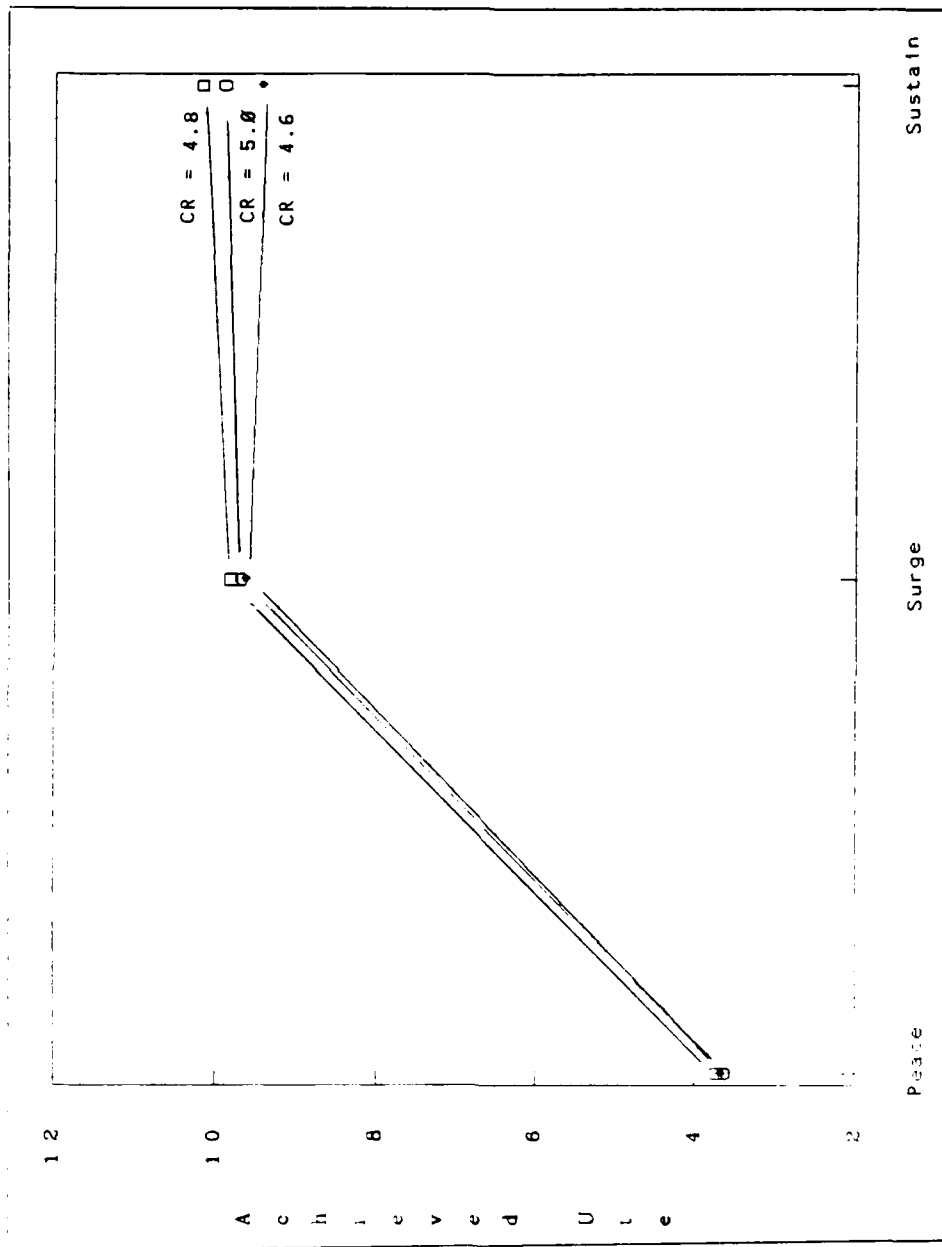


Fig. 4.4. Effect of CR(4.6,4.8,5.0) on AUR (NATO)

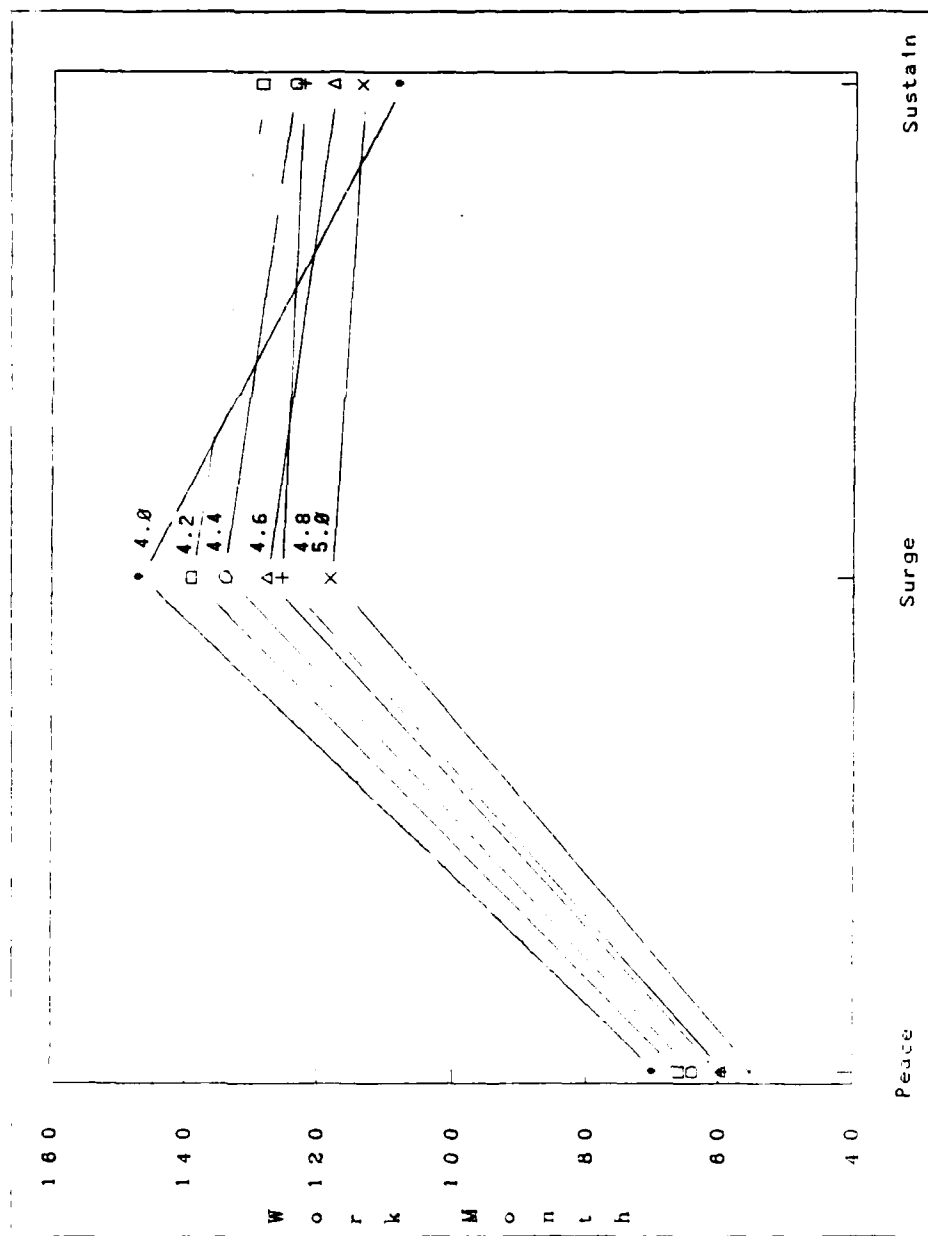


Fig. 4.5. Effect of CR on Avg Work Month (NATO)

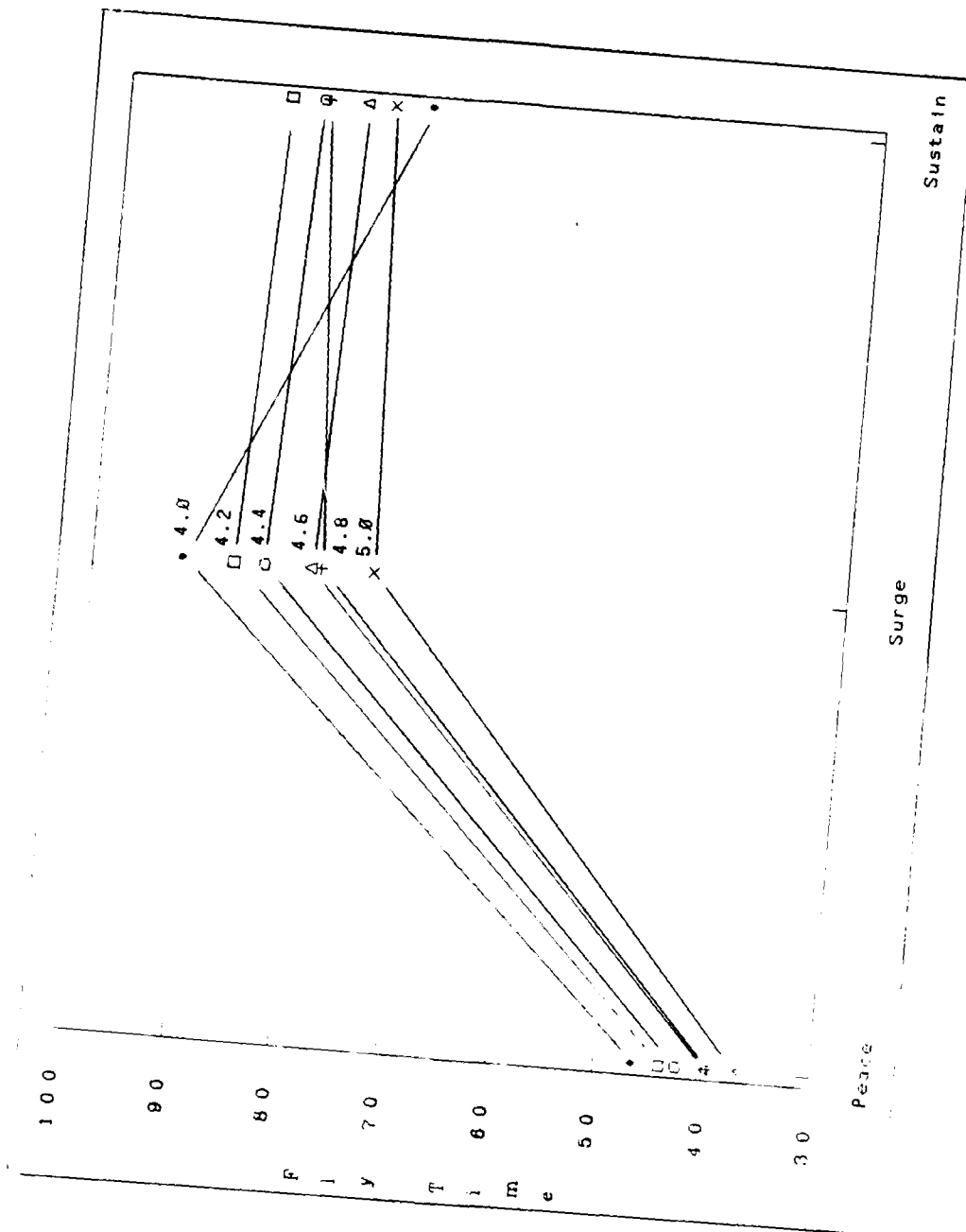


Fig. 4.6. Effect of CR on Avg Mo Fly Time (NATO)

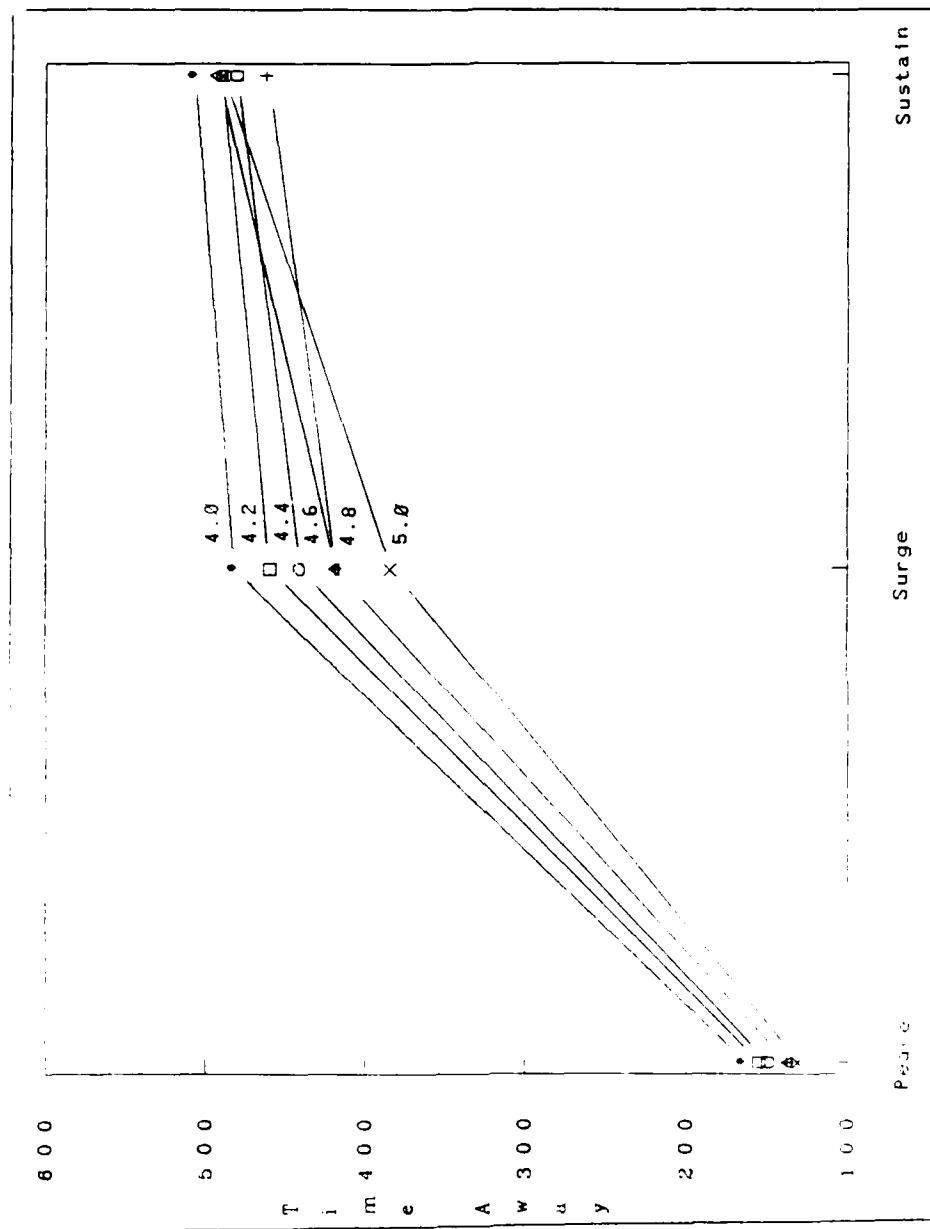


Fig. 4.7. Effect of CR on Time Away From Home

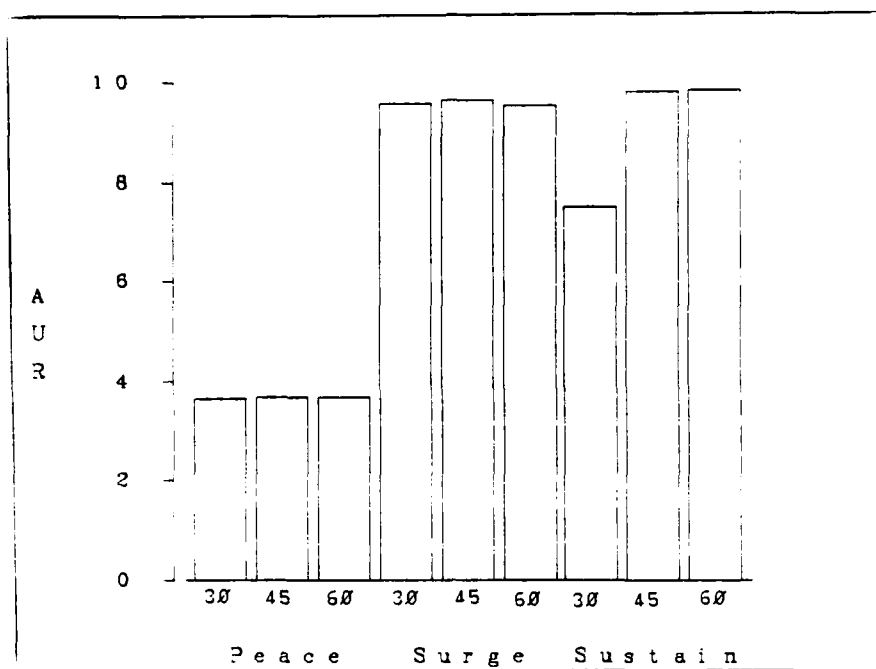


Fig. 4.8. Effect of Staging Policy on Ute Rate (NATO)

no crews available was an order of magnitude higher than other cases. Apparently, 4.0 crews per aircraft is simply not enough to maintain the desired utilization with the associated values of the other factors. The significant drop in work month, flying time, and achieved utilization going from surge to sustained when $CR = 4.0$ could be a result of flying time limits.

Staging Policy Sensitivity. Staging policy was given values 30, 45, and 60. There is apparently no benefit in staging more crews than one every 45 transits (See Figs. 4.8 -4.10). However, staging a crew for every 30 transits rather than 45 significantly reduces aircraft utilization in the sustained phase by approximately two hours a day.

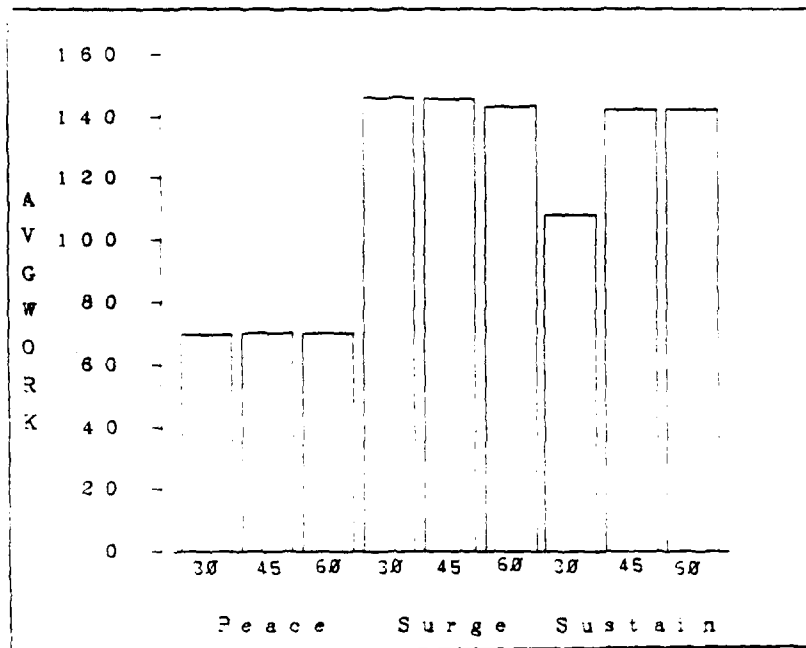


Fig. 4.9. Effect of Staging Policy on Work Month (NATO)

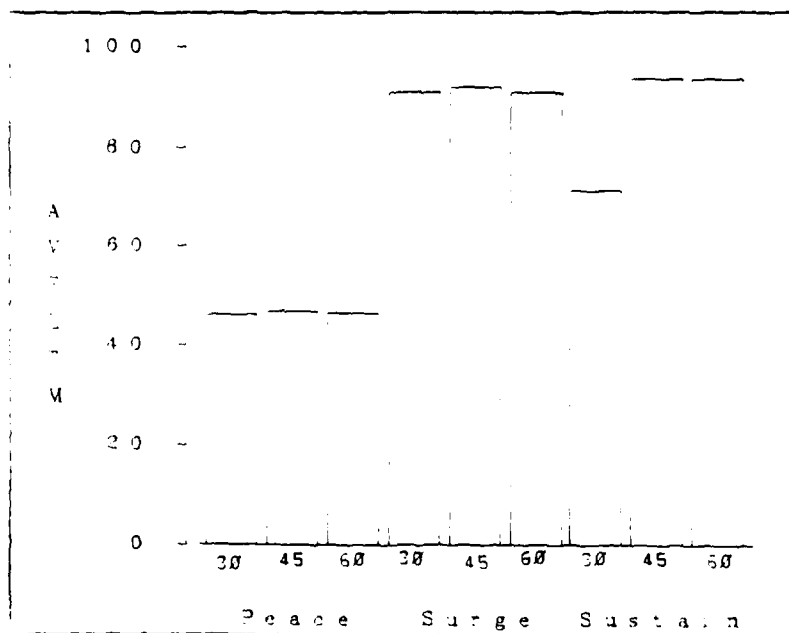


Fig. 4.10. Effect of Staging Policy on Avg Mo Fly Time (NATO)

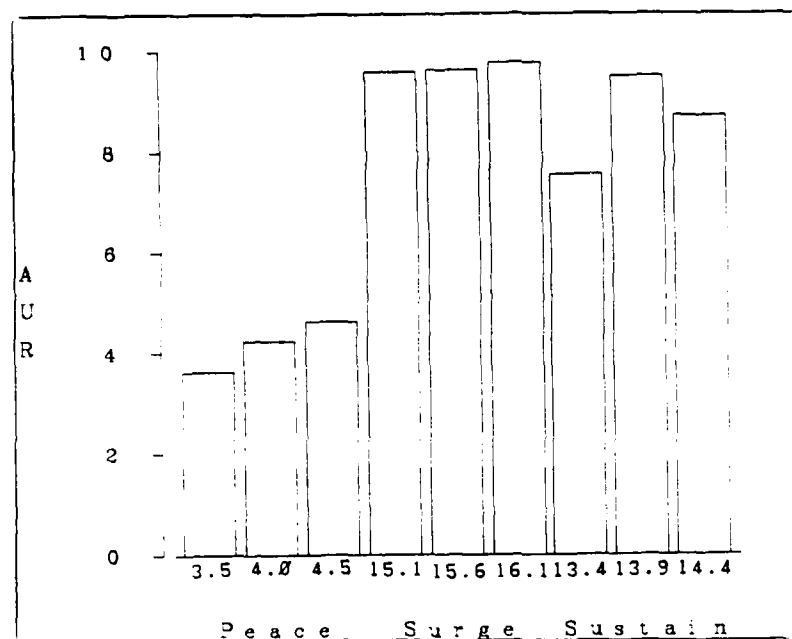


Fig. 4.11. Effect of Target Ute Rate on Achieved (NATO)

Target Utilization Rate Sensitivity. Peace, surge, and sustained TUR's were given values 3.5/15.1/13.4, 4.0/15.6/13.9, and 4.5/16.1/14.4. Increasing TUR beyond 4.0/15.6/13.9 reduces utilization rate, work month, and flying time in the sustained phase. This is quite possibly an indication that the sustained phase is the primary driver in restricting capability. It also indicates that the C-17 cannot be flown above the 13.9 projected utilization rate during a sustained conflict. Figs. 4.11-4.13 illustrate.

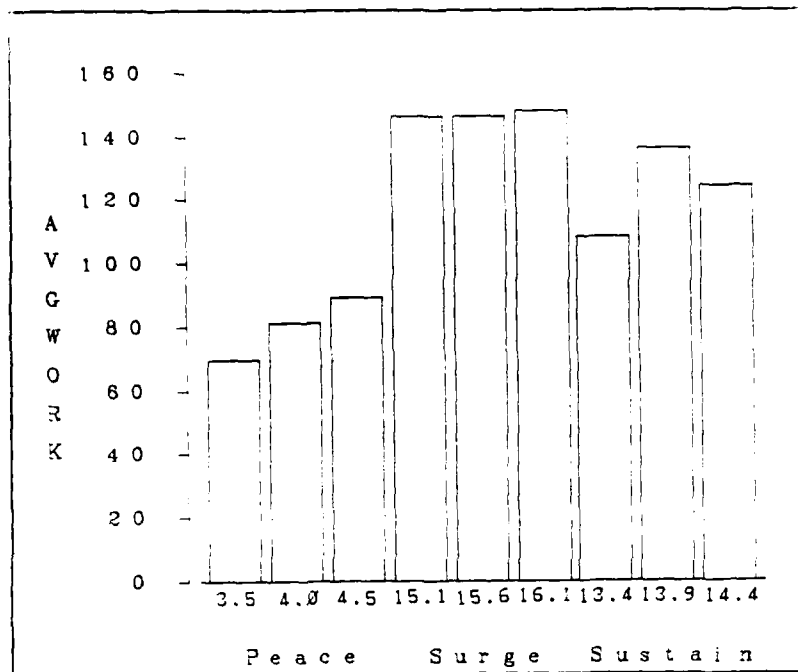


Fig. 4.12. Effect of Target Use Rate on Work Month (NATO)

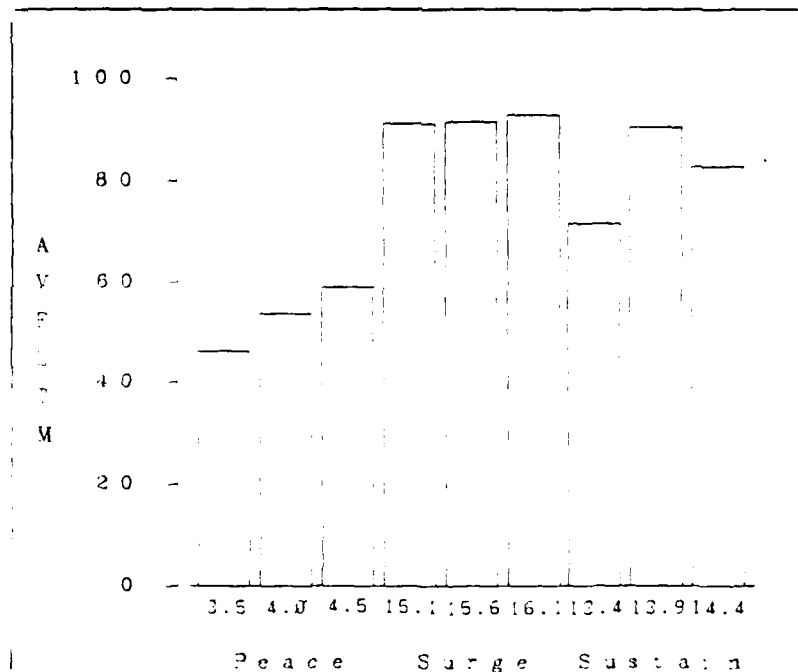


Fig. 4.13. Effect of Target Use Rate on Avg Mo Fly Time (NATO)

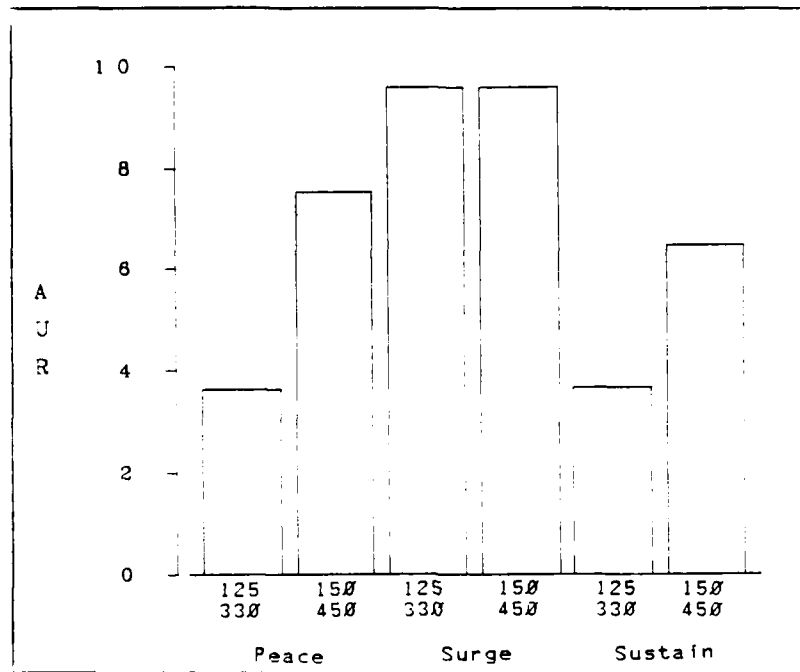


Fig. 4.14. Effect of 30/90 Day Limits on Achieved Ute (NATO)

Fly Time Limit Sensitivity. Fly time limits were evaluated at 125/330 and 150/450. Raising the limits had a positive impact in both peacetime and sustained operations whereas surge characteristics were unaffected (See Figs. 4.14-4.16). Aircraft utilization was increased by almost four hours a day in peacetime and almost three hours a day in sustained operations. This increased utilization obviously increases monthly flying time and the crew's work month; therefore, the length of conflict plays a definite role. These results indicate that the proposed increase in AFR 60-1 to 150/450 should definitely be considered.

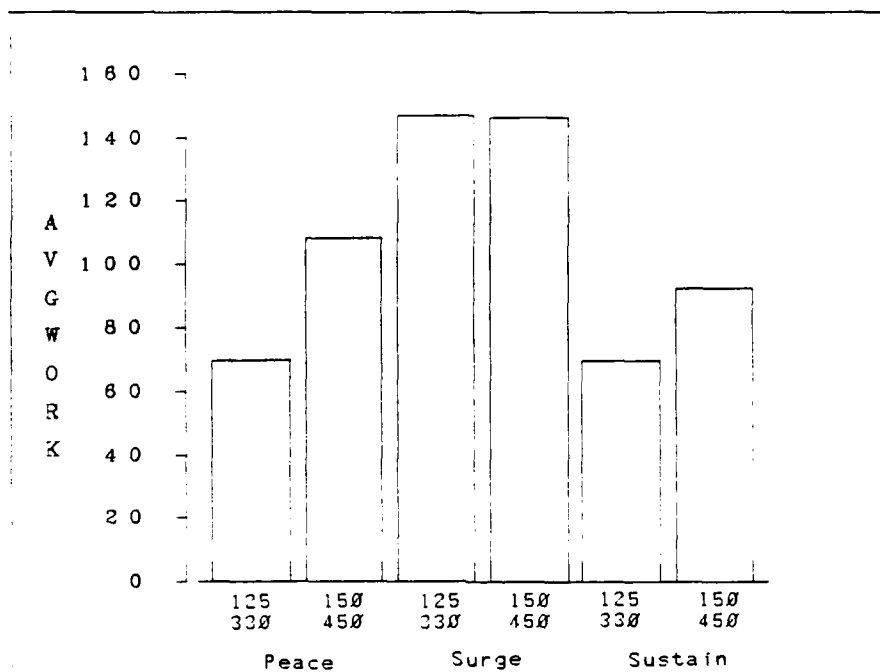


Fig. 4.15. Effect of 30/90 Day Limits on Work Month (NATO)

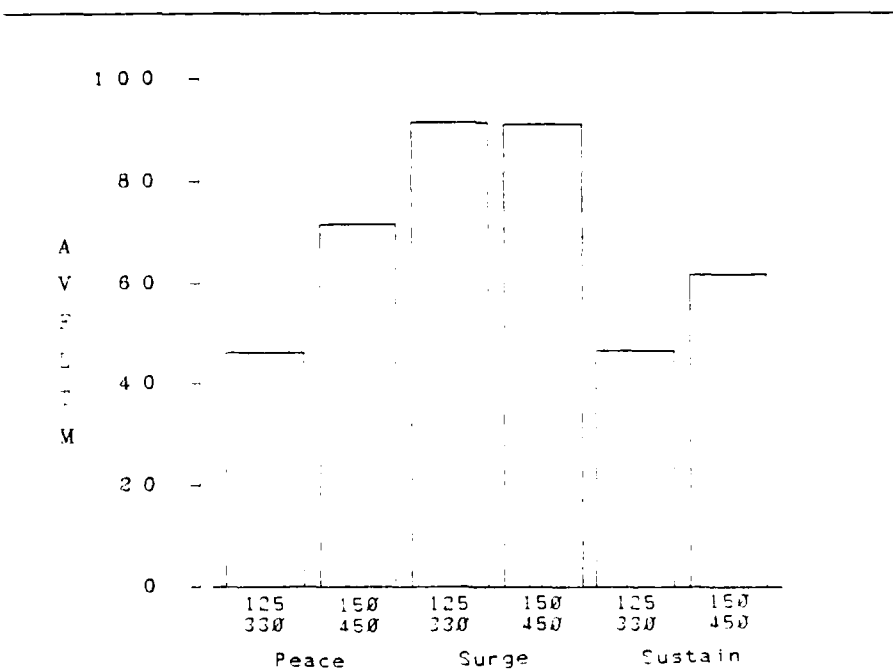


Fig. 4.16. Effect of 30/90 Day Limits on Avg Mo Fly Time (NATO)

V. Observations and Recommendations

Observations

This study examined the C-17's mission capability in terms of each aircraft's utilization and that utilization's effect on the aircrew. Specifically, average monthly flying times and average work months, as well as aircraft utilization, were found to be affected by changes in flying time limits, staging policies, target utilization rates, the number of crews, and the launch reliabilities.

The equations in the previous chapter show the relationships between these factors and responses for various levels of these parameters. The simulation then can accurately measure the dynamic effects of those changes. The simulation also gives the capability to vary work rules, change scenarios, analyze parameter values outside the ranges of the regressions, and answer many other "What if?" questions.

The sensitivity analysis yielded the following conclusions:

1. There is no benefit in staging more than one crew for every forty-five planned mission transits. Capability is significantly reduced, however, if thirty missions are used for the basis instead of forty-five.

2. Sustained capability is degraded if target utilization rates are increased above 4.0, 15.6, and 13.9

hours per day for peacetime, surge, and sustained respectively. These surge and sustained values were directed by the SECDEF for C-17 planning.

3. Monthly and quarterly flying time limits are a major restricting factor in both peacetime and sustained operations. Surge operations are only slightly affected.

4. 4.8 crews per aircraft yield the highest payoffs in utilization and crew workloads. 4.0 crews per aircraft are not enough. In-between these values, tradeoffs must be considered between the number of crews and the associated cost.

Future Studies

The value of this study lies in future research. As it exists now, valuable insights can be gained on the factor effects; but the model was not designed to produce optimal answers.

Costs need to be included in the analysis in order to weigh the effects of crew ratio changes. To say that 4.8 crews per aircraft yields the highest utilization is one thing; but is the extra \$305 million worth increasing the ratio from 4.6?

MAC does not have a staging policy for its contingencies. Major Charles Dillard, USAF/SAGM, has developed an analytic solution assuming exponential interarrival rates. This needs to be verified and expanded into a usable policy, as it is doubtful that (during a contingency) accurate

estimates of the number of mission transits or interarrival times can be made.

This simulation model could be an integral component of a decision support system. The system could mesh a multitude of attributes (cost, utilization, work month, etc.) and help decision makers to choose optimal crew ratios and optimal staging policies, not only to maximize aircraft utilization, but to maximize overall mission effectiveness.

Appendix A

Model Flow Charts

This appendix illustrates the flow of missions, crews, and aircraft through the SLAM model. It gives a pictorial representation of the interactions of the model segments.

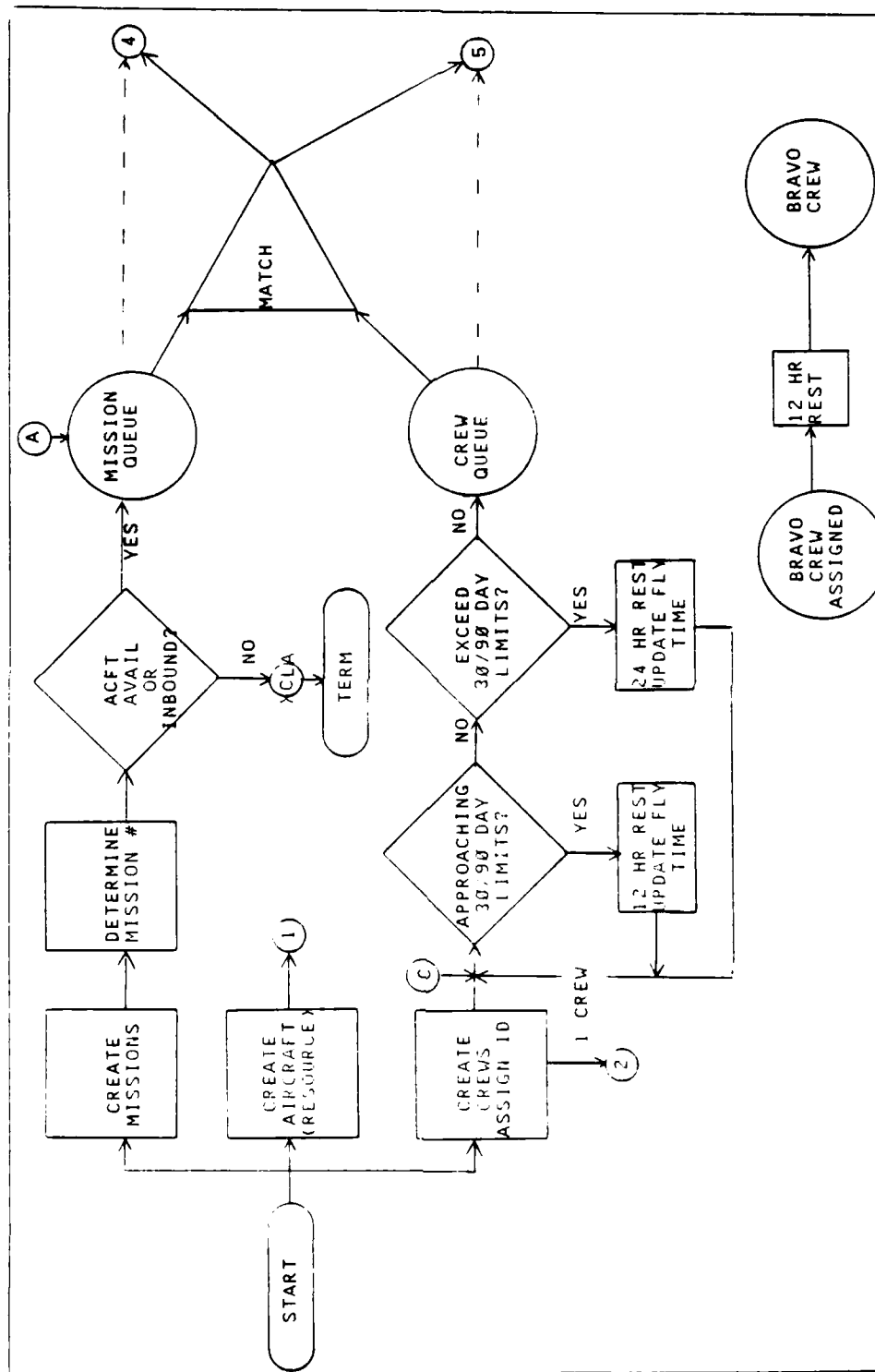


Fig. A.1. Generation

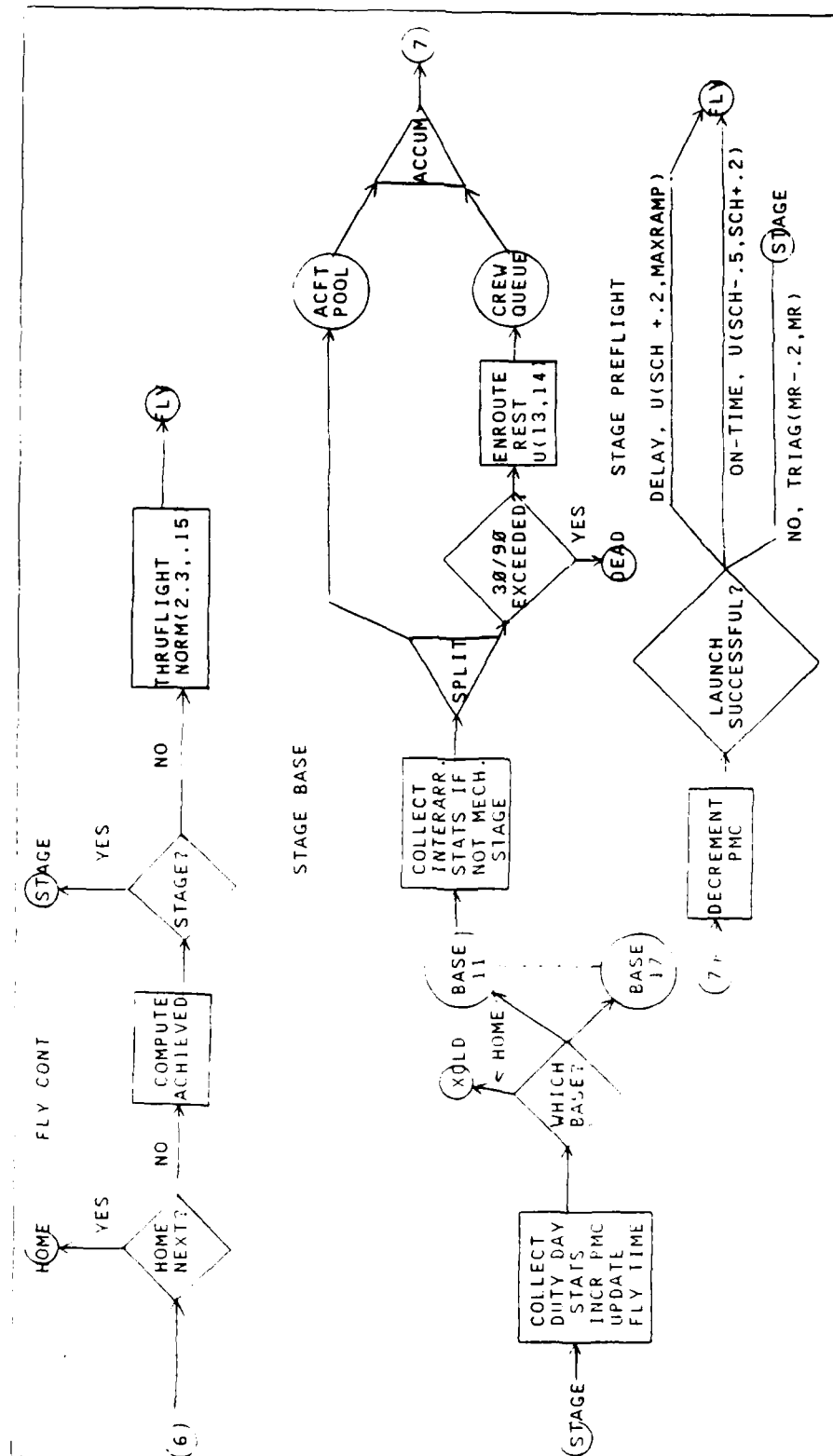


Fig. A.3. Enroute Base

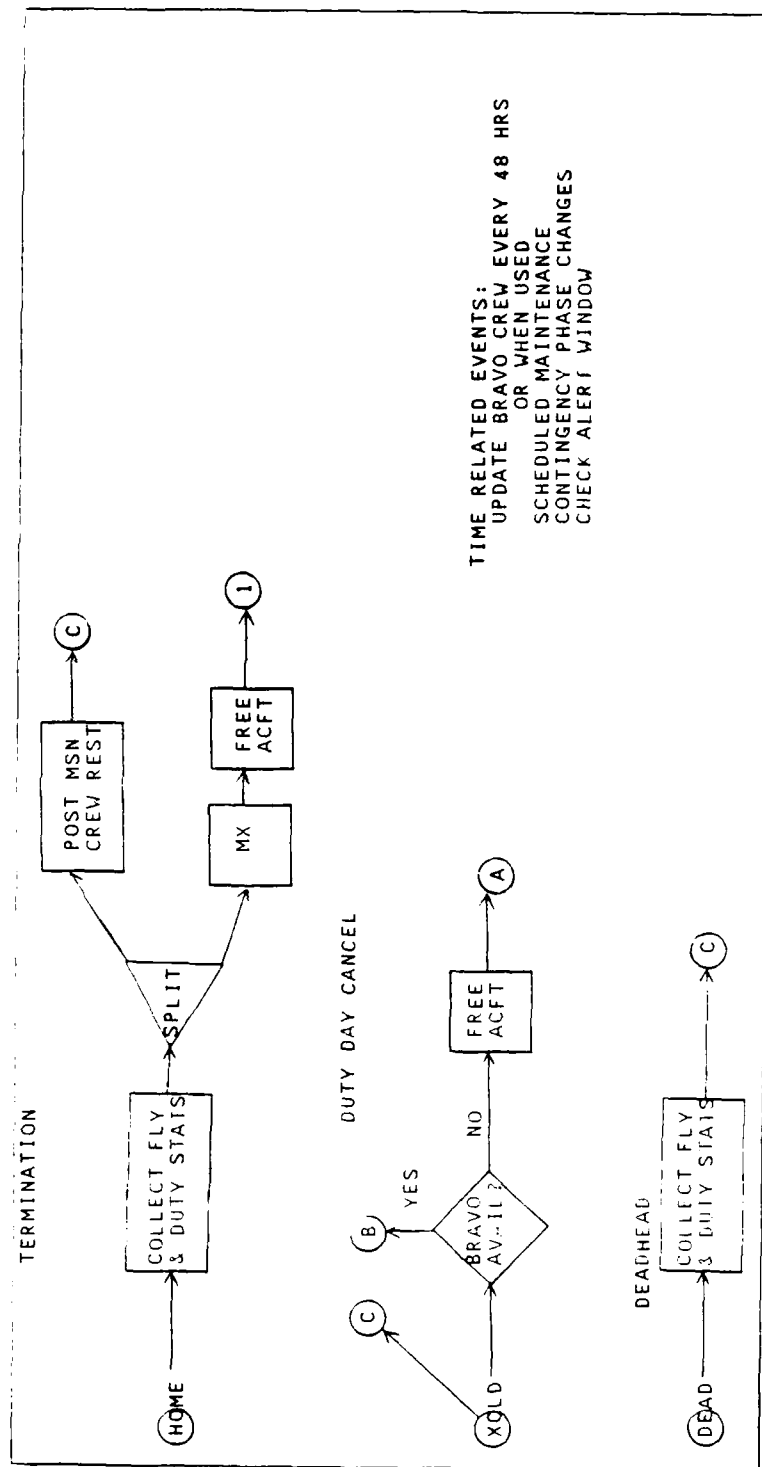


Fig. A.4. Termination

Appendix B

SLAM Network Code

```

SEN.BSUTTER,THESIS2,9/14/85,,,,,,,,72;
LIMITS,28,28,400;
TIMST,NNO(2),CREWS AT HOME,20/0/5;
TIMST,NNO(11),CREWS AT CYR;
TIMST,NNO(12),CREWS AT ESXX;
TIMST,NNO(14),CREWS AT CYXX;
TIMST,XX(51),MISSIONS CANCEL;
TIMST,XX(55),BURNOUT;
TIMST,XX(19),# ACFT PMC;
RECORD,TNOW,TIMEHRS,0,8,120; EVERY FIVE DAYS
VAR,XX(28),U,AUR;
VAR,XX(41),W,AVE WORK MONTH;
VAR,XX(42),F,AVE FLY HRSMD;
VAR,XX(46),T,AVE TIME AWAYMO;
PRIORITY,0,HVF(20)/11,HVF(20)/12,HVF(20)/13,HVF(20)/14,HVF(20)/15,HVF(20)/16,
HVF(20)/17,HVF(20);          GIVES PRIORITY TO A CREW THAT HAS BEEN MECH. STAGED
;*****
;                               INITIALIZATION
;                               USER INPUTS
;*****
INTL,XX(1)=30; STAGING POLICY
INTL,XX(2)=125; 30 DAY FLYING TIME LIMIT
INTL,XX(3)=300; 90 DAY FLYING TIME LIMIT
INTL,XX(4)=.949; ON TIME RELIABILITY
INTL,XX(5)=.044; DELAY RELIABILITY
INTL,XX(6)=.008; PROB OF RESCHEDULING
;          NOTE: XX(50)+XX(51)+XX(52)=1
INTL,XX(7)=.30; PERCENT AVAILABLE
INTL,XX(8)=4.0; CREW RATIO
;INSERT SCENARIO, TIMES, AND TARGET JTE. RATES INTO FILE 'ROUTE.'
;INSERT INITIAL NUMBER OF CREWS INTO FIRST CREATE STATEMENT & ASSIGN TO XX(47)
;# CREWS AVAIL=#C,R,#ACFT#C,R,#ACFT#C,R,PERCENT AVAILABLE
INTL,XX(9)=72; # CREWS AVAILABLE INITIALLY
INTL,XX(10)=5; PEACETIME MAX RAMP
INTL,XX(11)=5; PEACETIME ALERT WINDOW
INTL,XX(12)=10; # HRS AFTER WHICH A SCHED. MISSION IS CANCELLED IF NO CREW OR AC
;*****

NETWORK;
    RESOURCE(ACFT(10),1,4;          CREATE 10 AIRCRAFT

    CREATE,0,0,72; CREWS
    ENTER,1;
    ASSIGN,XX(17)=XX(17)+1,ATTRIB(14)=XX(17),ATTRIB(11)=0,ATTRIB(5)=1,
    ATTRIB(13)=10,ATTRIB(4)=1,ATTRIB(2)=0,ATTRIB(16)=TNOW,ATTRIB(9)=0,ATTRIB(21)=10;
    ;                               ATTRIB(14)=ID
    EODN,1;
    ACT,ATTRIB(14),EQ,1,QUEB;          POSITIONS FIRST BEARS CREW

```

```

ACT;
START ASSIGN, ATRIB(5)=1, ATRIB(1)=10, ATRIB(4)=1, ATRIB(9)=0,
      ATRIB(3)=0, ATRIB(10)=10; INIT BASIC CREW, PRESENT BASE, STAGE,
; MISSION, SORTIE FLY TIME, NEXT BASE
      ASSIGN, XX(14)=NNQ(2), 1;
      ACT/32, 12, XX(14), SE, 1, AND, ATRIB(11)+20, SE, XX(2), RET;   APPROACHING 30 LMT
      ACT/32, 12, XX(14), SE, 1, AND, ATRIB(12)+20, SE, XX(3), RET;   APPROACHING 90 LMT
      ACT;
      GOON, 1;
      ACT/20, 24, ATRIB(11), SE, XX(2), OR, ATRIB(12), SE, XX(3), RET;   ENTER 24 HOUR
; CREW REST IF 30 OR 90 DAY LIMIT EXCEEDED
      ACT,,, QUE2;
RET  EVENT, 10, 1;   UPDATE 30/90 FLY TIME
      ACT,,, START;
;
      QUEUE(10);
      ACT/24, 12;   BRAVO CREW REST
      QUE3 QUEUE(9);   BRAVO CREW FILE
      QUE2 QUEUE(2),,,, MAT1;   AWAIT MISSION
;*****CREATE MISSIONS*****
;*****
      CREATE, RNORM(XX(15), 1, 3), 0;   CREATE MISSION AT FREQ OF XX(15)
      MSN  EVENT, 4, 1;   DETERMINE MISSION
      ACT/10;   COUNT MISSIONS
      ASSIGN, ATRIB(2)=10, ATRIB(3)=0, ATRIB(4)=1, ATRIB(5)=1;   INTLC TO MATCH CREW
; IS AN AIRCRAFT AVAILABLE?
      ASSIGN, XX(16)=NNRSC(ACFT)+XX(17);   ACFT AVAIL + ACFT INBOUND
      GOON, 1;
      ACT,,, XX(16), LE, 0, XOLA;   CANCEL DUE TO NO ACFT
      ACT;
      ASSIGN, XX(17)=XX(17)+1;   ONE ACFT SPOKEN FOR
      G10  ASSIGN, ATRIB(15)=TNOW;
      QUE3 QUEUE(2),,,, MAT1;   MISSION QUEUE
      MAT1 MATCH, 5, QUE2, QUE3, QUE4, REST;   MATCH CREW WITH MISSION
      QUE6 ASSIGN, II=ATRIB(9);
      ACT,,, QUE6;
;*****
;*****CREW REST*****
;*****
      REST  GOON;
      ASSIGN, ATRIB(6)=11, ATRIB(7)=0, ATRIB(10)=0;   MISSION NUMBER, FLY TIME
; & TIME AWAY INIT=0
      ACT/1, 12,,,   CREW REST
      ASSIGN, ATRIB(16)=TNOW;
      AWAIT(4), ACFT;
      ASSIGN, XX(17)=XX(17)+1;   RESETS AVAIL OR PROJECTED ACFT
      GOON;
      ACT, 1,,,   TRAVEL

```

```

;*****
;                                     ****CREW SHOWS AT SODN****
;*****
QUES  QUEUE(5),,,,MAT2;                                     CREW
;
;                                     ****PREFLIGHT****
;                                     ****
QUES  QUEUE(6),,,,MAT2;                                     MISSION
MAT2  MATCH,9,QUE6/ACC,QUES/ACC;
ACC   ACCUM,2,2,LAST;          ATTACHES MSN TO CREW, RETAINS MSN ATTRIB
      ASSIGN,ATTRIB(13)=0,ATTRIB(6)=TNOW,ATTRIB(9)=TNOW;          LEE NUMBER INIT=0
      ASSIGN,XX(18)=XX(18)-1;
      SODN,1;
      ACT,EXPON(3,2,3),ATTRIB(17).NE.0,FLY!;          BRAVO CREW FLYING (ADD 1 HR TVL)
      ACT/22;
      ASSIGN,XX(19)=XX(19)-2;
      SODN,1;
      ACT/3,UNFRM(2,0,2,3,3),XX(4),FLY;                                     ON TIME
      ACT/27,UNFRM(2,3,XX(10),2),XX(5),FLY;          PREFLIGHT < MAX RAMP
      ACT/7,TRIAG(XX(19),XX(10),XX(10),3),XX(6),XCL;          RAMP EXCEEDED, RESCHEDULE
;*****
;                                     ****MISSION SORTIE****
;*****
FLY1  ASSIGN,ATTRIB(17)=0;                                     BRAVO UTILIZED
FLY   SODN,1;
      EVENT,5,1;          COMPUTE NEXT LEG & FLY TIME
      SODN,1;
      ACT/19,,TNOW+ATTRIB(13)-ATTRIB(6).GT.15,MECH;
;                                     WILL EXCEED DUTY DAY ON NEXT LEG
      ACT/24,,,;
      ASSIGN,XX(19)=ATTRIB(17)-.5,XX(20)=ATTRIB(17)+1.;
      ASSIGN,XX(21)=TRIAG(XX(19),ATTRIB(3),XX(20),4);
      ASSIGN,ATTRIB(17)=ATTRIB(17)+XX(21);
      ASSIGN,ATTRIB(15)=ATTRIB(15)+XX(21);
      ASSIGN,XX(18)=XX(18)+1;
      SODN,1;
      ACT/5,XX(21),ATTRIB(17).EG.XX(22),HOME;          NEXT HOME
      ACT/5,XX(21);
      ASSIGN,XX(18)=XX(18)-1;
      ASSIGN,XX(27)=TNOW-XX(24),XX(25)=XX(26)-XX(27);
      ASSIGN,XX(23)=XX(23)+XX(27)+24,XX(29)=XX(25)+XX(29)-ATTRIB(7)+XX(29);
;                                     COMPUTE ACHIEVED UTE RATE
;*****
;                                     ****ENROUTE STOPS****
;*****
      SODN,1;
      ACT/2,ATTRIB(4).EG.1,STAGE;          STAGE OPEN
      ACT;
      SODN;
      ASSIGN,ATTRIB(11)=ATTRIB(12);
      ACT/8,ENORM(2,2,15,2),FLY;          SCHEDULED END TIME

```



```

      ACT,,,Q112;
Q111  QUEUE(11),,,,MAT3;                                ACFT
Q112  QUEUE(11),,,,MAT3;                                CREWS AVAIL
MAT3   MATCH,5,Q111/AX1,Q112/AC1;                        MATCH ACFT WITH CREW
AX1    GOON;
      ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
      XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
      XX(37)=ATRIB(19);
AC1    ACCUM,2,2,LAST;
      ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
      ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
      ATRIB(19)=XX(37),ATRIB(20)=0;
      ACT,,,CONT;
;
;
EGXX   GOON,1;                                           EGXX STAGE
      ACT,,ATRIB(1),EQ,ATRIB(2),ME12;
      ACT;
      COLCT,BET,INTER AT EGXX,,1;
ME12   GOON,2;
      ACT,,,Q121;
      ACT;
      GOON,1;
      ACT/21,RNDNM(26,,3,,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
      ACT;
EG      GOON;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATRIB(16)=TNOW;
      ACT,,,Q122;
Q121   QUEUE(12),,,,MAT4: ACFT
Q122   QUEUE(12),,,,MAT4: CREWS AVAIL
MAT4    MATCH,5,Q121/AX2,Q122/AC2;
AX2     GOON;
      ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
      XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
      XX(37)=ATRIB(19);
AC2     ACCUM,2,2,LAST;
      ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
      ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
      ATRIB(19)=XX(37),ATRIB(20)=0;
      ACT,,,CONT;
;
;
KPXX   GOON,1;                                           KPXX STAGE
      ACT,,ATRIB(1),EQ,ATRIB(2),ME17;
      ACT;
      COLCT,BET,INTER AT KPXX,,1;
ME17   GOON,2;
      ACT,,,Q171;
      ACT;
      GOON,1;

```

```

ACT/21,P,NORM(24,,3,,3),ATRI(11).GE.XX(25).OR.ATRI(12).GE.XX(3).DEAD;
ACT;
KP  GOON;
    ACT,UNFRM(13,,14,,3);
    ASSIGN,ATRI(16)=TNOW;
    ACT,,,Q132;
Q131 QUEUE(23),,,,MAT5; ACFT
Q132 QUEUE(13),,,,MAT5; CREWS AVAIL W/2
MAT5 MATCH,5,Q131/AX3,Q132/AC3;
AX3  GOON;
    ASSIGN,XX(31)=ATRI(1),XX(32)=ATRI(2),XX(33)=ATRI(3),
    XX(34)=ATRI(4),XX(35)=ATRI(9),XX(36)=ATRI(13),
    XX(37)=ATRI(19);
AC3  ACCUM,2,2, LAST;
    ASSIGN,ATRI(1)=XX(31),ATRI(2)=XX(32),ATRI(3)=XX(33),
    ATRI(4)=XX(34),ATRI(9)=XX(35),ATRI(13)=XX(36),
    ATRI(19)=XX(37),ATRI(20)=0;
    ACT,,,CONT;
;
;
CYXX STAGE
CYXX GOON,1;
    ACT,,ATRI(1).EQ.ATRI(2),ME14;
    ACT;
    COLCT,BET,INTER AT CYXX,,1;
ME14 GOON,2;
    ACT,,,Q141;
    ACT;
    GOON,1;
    ACT/21,P,NORM(24,,3,,3),ATRI(11).GE.XX(2).OR.ATRI(12).GE.XX(3).DEAD;
    ACT;
CYX  GOON;
    ACT,UNFRM(13,,14,,3);
    ASSIGN,ATRI(16)=TNOW;
    ACT,,,Q142;
Q141 QUEUE(24),,,,MAT6; ACFT
Q142 QUEUE(14),,,,MAT6; CREWS AVAIL
MAT6 MATCH,5,Q141/AX4,Q142/AC4;
AX4  GOON;
    ASSIGN,XX(31)=ATRI(1),XX(32)=ATRI(2),XX(33)=ATRI(3),
    XX(34)=ATRI(4),XX(35)=ATRI(9),XX(36)=ATRI(13),
    XX(37)=ATRI(19);
AC4  ACCUM,2,2, LAST;
    ASSIGN,ATRI(1)=XX(31),ATRI(2)=XX(32),ATRI(3)=XX(33),
    ATRI(4)=XX(34),ATRI(9)=XX(35),ATRI(13)=XX(36),
    ATRI(19)=XX(37),ATRI(20)=0;
    ACT,,,CONT;
;
;
EDXX STAGE
EDXX GOON,1;
    ACT,,ATRI(1).EQ.ATRI(2),ME15;
    ACT;

```

```

      COLCT,BET,INTER AT EDXX,,1;
ME15  GOON,2;
      ACT,,,Q151;
      ACT;
      GOON,1;
      ACT/21,RNORM(24,,3,,3),ATTRIB(11).GE.XX(2).OR.ATTRIB(12).GE.XX(3),DEAD;
      ACT;
ED     GOON;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATTRIB(16)=TNOW;
      ACT,,,Q152;
Q151  QUEUE(25),,,,MAT7; ACFT
Q152  QUEUE(15),,,,MAT7; CREWS AVAIL
MAT7  MATCH,5,Q151/AX5,Q152/AC5;
AX5   ASSIGN,XX(31)=ATTRIB(1),XX(32)=ATTRIB(2),XX(33)=ATTRIB(3),
      XX(34)=ATTRIB(4),XX(35)=ATTRIB(9),XX(36)=ATTRIB(13),
      XX(37)=ATTRIB(19);
AC5   ACCUM,2,2,LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37),ATTRIB(20)=0;
      ACT,,,CONT;
;
;
ENXX  GOON,1;
      ACT,,ATTRIB(1).EQ.ATTRIB(2),ME16;
      ACT;
      COLCT,BET,INTER AT ENXX,,1;
ME16  GOON,2;
      ACT,,,Q161;
      ACT;
      GOON,1;
      ACT/21,RNORM(24,,3,,3),ATTRIB(11).GE.XX(2).OR.ATTRIB(12).GE.XX(3),DEAD;
      ACT;
EN     GOON;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATTRIB(16)=TNOW;
      ACT,,,Q162;
Q161  QUEUE(26),,,,MAT8; ACFT
Q162  QUEUE(16),,,,MAT8; CREWS AVAIL
MAT8  MATCH,5,Q161/AX6,Q162/AC6;
AX6   ASSIGN,XX(31)=ATTRIB(1),XX(32)=ATTRIB(2),XX(33)=ATTRIB(3),
      XX(34)=ATTRIB(4),XX(35)=ATTRIB(9),XX(36)=ATTRIB(13),
      XX(37)=ATTRIB(19);
AC6   ACCUM,2,2,LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37),ATTRIB(20)=0;
      ACT,,,CONT;

```

ENXX STAGE

```

;
KTIK 600N,1;
ACT,,ATRIB(1).EQ.ATRIB(2),ME17;
ACT;
COLCT,2ET,INTER AT KTIK,,1;
ME17 600N,2;
ACT,,,Q171;
ACT;
600N,1;
ACT/21,RNORM(24,,3,,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
ACT;
KT 600N;
ACT,UNFRM(13,,14,,3);
ASSIGN,ATRIB(16)=TNOW;
ACT,,,Q172;
Q171 QUEUE(27),,,,MAT9; ACFT
Q172 QUEUE(17),,,,MAT9; CREWS AVAIL
MAT9 MATCH,5,Q172/AC7;
AX7 ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
XX(37)=ATRIB(19);
AC7 ACCUM,2,2,LAST;
ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
ATRIB(19)=XX(37),ATRIB(20)=0;
ACT,,,CONT;
;*****
; *****MISSION CONTINUATION*****
;*****
CONT 600N;
ACT/23; ENROUTE DEPARTURES
ASSIGN,XX(19)=ATRIB(19)-.5,XX(20)=ATRIB(19)+.2,XX(38)=XX(10)-2;
ASSIGN,XX(18)=XX(18)-1;
ASSIGN,ATRIB(1)=ATRIB(2),ATRIB(6)=TNOW,1; PRESENT NODE=ATRIB(2)
ACT/4,UNFRM(XX(19),XX(20)),XX(4),FLY; NO MAJOR MX
ACT/23,UNFRM(XX(20),XX(10),2),XX(5),FLY; DELAY
ACT/6,TRIAG(XX(33),XX(10),XX(10),3),XX(6),STAGE; RAMP EXCEEDED
;*****
; *****CK MISSION QUEUES FOR WAIT TIME AND ALERT WINDOWS*****
;*****
CREATE,1,1,,3840,;
EVENT,2;
EVENT,12;
TERM;
;*****
; *****HOME*****
;*****
HOME 500N;
EVENT,10,1; UPDATE 30/90 TIME
COLCT,INT(3),MISSION LENGTH; TRACK MSN LENGTHS
COLCT,INT(5),LAST DUTY DAY; TRACK FINAL DUTY DAY

```

```

ASSIGN, ATRIB(10)=ATRIB(10)+TNOW-ATRIB(9);          TRACK TIME AWAY
GOON;
ASSIGN, XX(18)=XX(18)-1;
ASSIGN, XX(26)=XX(26)+ATRIB(7), ATRIB(7)=0;          ACCUMULATE FLYING TIME
ASSIGN, XX(25)=XX(26)-XX(27);                        FLY TIME THIS PHASE
ASSIGN, XX(30)=XX(30)+TNOW-ATRIB(6);                  ACCUM. DUTY TIME
ASSIGN, XX(23)=TNOW-XX(24), XX(39)=XX(30)-XX(40);    DUTY TIME THIS PHASE
ASSIGN, XX(41)=XX(9)*XX(23)/730.56, XX(41)=XX(39)/XX(41);  AVG WORK MONTH
ASSIGN, XX(42)=XX(9)*XX(23)/730.56, XX(42)=XX(25)/XX(42);  AVG FLY HRS
ASSIGN, XX(43)=XX(43)+TNOW-ATRIB(8);                  CUM. TIME AWAY
ASSIGN, XX(44)=XX(43)-XX(45);                          TIME AWAY THIS PHASE
ASSIGN, XX(46)=XX(9)*XX(23)/730.56, XX(46)=XX(44)/XX(46);  AVG TIME AWAY
ASSIGN, XX(17)=XX(17)+1;                              ACFT INBOUND
COLCT, XX(25), SYS FLY TIME, , 2;                     FLY TIME THIS PHASE
ACT, USERF(10), , START;                             CREW AVAIL.
ACT, USERF(3);                                         ACFT MX
FREE, ACFT/1;
ASSIGN, XX(17)=XX(17)-1;                              RESET COUNTER, ACFT INBOUND
ASSIGN, XX(18)=XX(18)+1;
TERM;

;*****
;                               ****UNSUCCESSFUL HOMESTATION PREFLIGHT****
;*****
XCL  GOON;                                             RAMP EXCEEDED
ASSIGN, XX(30)=XX(30)+TNOW-ATRIB(6);                 ADD DUTY TIME
ASSIGN, XX(18)=XX(18)+1;
GOON, 2;
ACT...START;                                          CREW BACK TO CREW REST
ACT, 9, UNFRM(3,12,2);
EVENT, 1, 1;                                         IS BRAVO AVAIL?
ACT/25, ATRIB(17).NE.0, QUES;                       BRAVO AVAIL-REMATCH
ACT;
GOON, 2;
ACT...Q10;                                           RESCHEDULE MISSION
FREE, ACFT/1;
TERM;
XCLE GOON;                                           DUTY DAY EXCEEDED AT HOME
ASSIGN, XX(30)=XX(30)+TNOW-ATRIB(6);                 ADD DUTY TIME
GOON, 2;
ACT...START;
ACT;
EVENT, 1, 1;                                         IS BRAVO AVAIL?
ACT, ATRIB(17).NE.0, QUES;                           BRAVO AVAIL-REMATCH
ACT;
GOON, 2;
ACT...Q10;                                           RESCHEDULE MISSION
ACT;
FREE, ACFT/1;
TERM;
XCLA GOON, 1;
ACT/18;                                              COUNT MISSIONS CANCELLED DUE TO NO ACFT

```

```

TERM;
;
;*****SCHEDULED MAINTENANCE*****
;
;A.C.I AND REFURB NOT ACCOMPLISHED DURING SURGE
;HOMESTATION CHECK: 2 DAYS DOWN EACH 60 DAYS
CREATE,XX(47),0;
AWAIT(1),ACFT;
ASSIGN,XX(18)=XX(18)-1;
ACT/20,RNORM(48.,1.,3);
ASSIGN,XX(18)=XX(18)+1;
FREE,ACFT/1;
TERM;
;REFURBISHMENT: 10 DAYS DOWN EACH 18 MOS
CREATE,XX(48),0;
GOODN,1;
ACT,,XX(49),EQ,1,TERM;
ACT;
AWAIT(1),ACFT;
ASSIGN,XX(18)=XX(18)-1;
ACT/30,RNORM(240.,5.,3);
ASSIGN,XX(18)=XX(18)+1;
FREE,ACFT/1;
TERM TERM;
;A.C.I. (REPLACING ISDCH): 10 DAYS DOWN EACH 18 MOS
;ARBITRARILY START AT 100
CREATE,XX(50),100;
GOODN,1;
ACT,,XX(49),EQ,1,TERM;
ACT;
AWAIT(1),ACFT;
ASSIGN,XX(18)=XX(18)-1;
ACT/71,RNORM(720.,10.,3);
ASSIGN,XX(18)=XX(18)+1;
FREE,ACFT/1;
TERM;
;*****DEADHEAD HOME: EXCEEDED FLY TIME*****
;
DEAD QUEUE(7);
ACT;
COLCT,INT(2),MISSION LENGTH: TRACK MISSION LENGTH
ASSIGN, ATRIB(10)=ATRIB(10)+TNOW-ATRIB(9); TIME AWAY
ASSIGN,XX(20)=XX(20)+UNFRM/9.,16.,2),XX(27)=TNOW-XX(24);ADD ON TIME TO ST/
ASSIGN,XX(42)=XX(42)+TNOW-ATRIB(9),XX(44)=XX(42)-(XX(45);
ASSIGN,XX(46)=XX(9)+XX(27)/710.56,XX(46)=XX(44)+XX(46); AWAY
ASSIGN,XX(39)=XX(20)+XX(40);
ASSIGN,XX(41)=XX(9)+XX(27)/730.56,XX(41)=XX(39)+XX(41); WORK
GOODN;
ASSIGN,XX(26)=XX(26)+ATRIB(7),ATRIB(7)=0; ACCUM FLY TIME
ASSIGN,XX(25)=XX(26)+XX(27);

```

```

ASSIGN,XX(42)=XX(9)*XX(23)/770.55,XX(42)=XX(25)/XX(42);          FLY
COLCT,XX(25),SYS FLY TIME,,2;
ACT,USEFF(2),,START;          CREW AVAIL.
ACT;
TERM;
ENDNETWORK;

```

```

;*****
;          ****DESCRIPTION OF COMPONENTS****
;*****
;QUEUES
; 1) HOME STATION SCHEDULED MAINTENANCE
; 2) CREW PRIOR TO MISSION ASSIGNMENT
; 3) MISSION
; 4) AWAIT ACFT
; 5) CREW PRIOR TO MATCHING WITH MISSION (MAT2)
; 6) MSN PRIOR TO MATCHING WITH CREW (MAT2)
; 7) DEADHEAD TRANSITION
; 8) BRAVO CREW FILE
; 9) BRANCHING FOR WINDOW (FORTRAN)
; 10) ENTRY TO BRAVO IF CREW REST NEEDED
; 11-17) CREW ENROUTE
; 20-27) ACFT ENROUTE
;ACTIVITIES
; 1) CREW REST
; 2) STAGE
; 3) PREFLIGHT HOME STATION - ON TIME
; 4) PREFLIGHT/RY AT STAGE
; 5) FLY
; 6) RAMP EXCEEDED ENROUTE
; 7) RAMP EXCEEDED AT HOME
; 8) QUICK TURN END TIME
; 9) MY AFTER XCL
; 10) NUMBER OF MISSIONS
; 11-17) BASE COUNT
; 18) CANCEL NO ACFT
; 19) DUTY DAY CANCEL
; 20) EXCEEDS 10/90 LIMITS AT HOME
; 21) EXCEEDS 10/90 LIMITS IN SYSTEM
; 22) # MSNS NOT CANCELLED PRIOR TO PREFLIGHT
; 23) # ENROUTE MISSIONS
; 24) DEPARTURES
; 25) BRAVO FLIES
; 26) DUTY DAY XCL AT HOME
; 27) PREFLIGHT HOME STATION - LATE DEPARTURE
; 28) PREFLIGHT ENROUTE - LATE DEPARTURE
; 29) HSC
; 30) REFURB
; 31) A.I.I.

```

; 20) APPROACHING 20 DAY LIMITS
 ; 30) APPROACHING 30 DAY LIMITS
 ; 40) CREW REST FOR BRAVO
 ; USERFS
 ; 1) FLY TIME
 ; 2) HOME CREW REST
 ; 3) MX
 ; 4) CALC MISSION FREQ TO MEET TUR
 ; 5) STAGE

;ATTRIBUTES

; 1) PRESENT NODE
 ; 2) NEXT NODE
 ; 3) SORTIE FLY TIME
 ; 4) STAGE=1
 ; 5) BASIC=1
 ; 6) SHOW TIME FOR DAY
 ; 7) CUM. FLY TIME
 ; 8) SHOW TIME FOR MSN
 ; 9) ROUTE NUMBER
 ; 10) CUM. TIME AWAY FROM HOME
 ; 11) CUM. FLY TIME FOR 30 DAYS
 ; 12) CUM. FLY TIME FOR 90 DAYS
 ; 13) WHICH LEG NUMBER
 ; 14) CREW ID
 ; 15) DAILY CUM FLY TIME
 ; 16) START TIME MISC
 ; 17) MISSION FOR BRAVO CREW
 ; 18) EVENT NUMBER
 ; 19) SCHED GROUND TIME

;SLAM

; 1) STAGING POLICY - 1 CREW FOR EVERY 20 ARRIVALS
 ; 2) 20 DAY FLY TIME LIMIT
 ; 3) 90 DAY FLY TIME LIMIT
 ; 4) ON-TIME PROBABILITY
 ; 5) DELAY PROBABILITY
 ; 6) RESCHEDULE PROBABILITY
 ; 7) PERCENT AVAILABLE
 ; 8) CREW RATIO
 ; 9) # CREWS CREATED
 ; 10) MAX SAME TIME
 ; 11) ALERT WINDOW
 ; 12) # OF HOURS AFTER WHICH MSN IS CANCELLED IF NO ACFT OR CREW
 ; 13) COUNTER FOR CREW ID
 ; 14) WND(10)
 ; 15) MISSION FREQUENCY
 ; 16) RESOURCE COUNT OF INBOUND ACFT
 ; 17) ACFT HOME PENDING MAINTENANCE
 ; 18) # PNC ACFT
 ; 19) MISC
 ; 20) MISC

```

; 21) MISC
; 22) NUMBER OF LEGS
; 23) TIME SINCE PHASE CHANGE
; 24) TIME OF PHASE CHANGE
; 25) FLY TIME SINCE PHASE CHANGE
; 26) SYSTEM FLY TIME
; 27) FLY TIME AT PHASE CHANGE
; 28) UTE RATE
; 29) * ACFT CREATED
; 30) ACCUM. DUTY HOURS
; 31-37) SAVE ATTRIBUTES AT STAGE BASES
; 38) MISC
; 39) DUTY TIME SINCE PHASE CHANGE
; 40) DUTY TIME AT PHASE CHANGE
; 41) AVG WORK MONTH
; 42) AVG MO FLY HOURS
; 43) TOTAL TIME FROM HOME
; 44) TIME AWAY SINCE PHASE CHANGE
; 45) TIME AWAY AT PHASE CHANGE
; 46) AVG MO TIME FROM HOME
; 47) FREQ OF HSC
; 48) FREQ OF REFURBISHMENT
; 49) 0=PEACE, 1=SURGE, 2=SUSTAINED
; 50) FREQ OF ACI
; 51) RENEGES FROM RESCHEDULING
; 52) STAGE CREW UTILIZED
; 53) INDEX FOR CREW REST (0=PEACE/SUSTAINED, 4=SURGE)
; 54) 20 DAY FLY TIME
; 55) 30 DAY FLY TIME
; 56) * EXCEEDING ALERT WINDOW
;
INIT, 1, 12840:          175 DAYS (45 PEACE, 45 SURGE, 45 SUSTAINED) + 500 HR WARMUP
88888, 111111 NO, 222212 NO, 333313 NO, 444414 NO, 555515 NO, 666616 NO,
777717 NO, 888818 NO, 999919 NO, 10101101101101 NO;
MONTE, CLEAR, 500:
MONTE, SUMRY, 1581, 1080:
SIMULATE;
FIN:
WARMUP
SUMMARY EACH PHASE

```

Appendix C

FORTRAN Main

```
PROGRAM MAIN
  DIMENSION NSET(40000)
  COMMON/SCOM1/ATRIB(100),DD(100),DEL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
  COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SET(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREDSG(10),TURSU,HREMO,EXPFLY,SB
  COMMON/FLY/ACFLTM(160,91),MAN,N
  COMMON QSET(40000)
  EQUIVALENCE(NSET(1),QSET(1))
  NNSET=40000
  NCRDR=5
  NPRNT=6
  NTAPE=7
  NPLOT=2
  CALL BLAM
  STOP
  END
```

SUBROUTINE EVENT(JEVNT)

```
  GO TO (1,2,3,4,5,6,7,8,9,10,11,12) JEVNT
1  CALL BRAVO
   RETURN
2  CALL CANCEL
   RETURN
3  CALL MIDUP
   RETURN
4  CALL MISSION
   RETURN
5  CALL NEXT
   RETURN
6  CALL STAGECF
   RETURN
7  CALL BURGE
   RETURN
8  CALL SUSTAIN
   RETURN
9  CALL LFFAW
   RETURN
10 CALL JPELTM
   RETURN
11 CALL WARMUP
   RETURN
12 CALL WINDOW
   RETURN
  END
```

```

SUBROUTINE BRAVO
C *****IS BRAVO CREW AVAILABLE?
COMMON/SCDM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NPRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON QSET(40000)
DIMENSION NSET(40000)
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION A(30)
NQ=NNQ(8)
IF (NQ.EQ.0) GO TO 12
CALL RMOVE(1,B,A)
A(9)=ATRIB(9)
A(6)=TNOW
A(8)=TNOW
A(17)=1
XX(52)=1
CALL FILEM(5,A)
ATRIB(17)=1
12 CALL UPBRAV
RETURN
END

```

```

SUBROUTINE CANCEL
C *****CANCEL IF IN SCHEDULED MSN QUEUE(3) FOR MORE THAN 12 HRS.
COMMON/SCDM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NPRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
DIMENSION NSET(40000)
COMMON QSET(40000)
INTEGER RANK
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION B(34)
RANK=1
NY=NNQ(3)
9 IF (RANK.GT.NY) GO TO 11
CALL COPYRANK(1,B)
TT=TNOW-B(15)
IF (TT.LE.XX(12)) GO TO 11
CALL RMOVERANK(1,B)
NY=NY-1
XX(51)=XX(51)+1
XX(17)=XX(17)+1
GO TO 9
11 RETURN
END

```

```

SUBROUTINE MIDUP
C *****CHANGE DAY FOR UPFLTM
C AND CARRY FORWARD PREVIOUS DAY'S TIME IF NONE FLOWN TODAY
COMMON/SCDM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NPRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/FLY ACFLTM(150,2),MAN,N

```

```

      IF (N.EQ.91) THEN
        N=1
      ELSE
        N=N+1
      ENDIF
      DO 30 L=1,160
        IF (N.EQ.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1)) THEN
          ACFLTM(L,N)=ACFLTM(L,91)
        ELSEIF (N.EQ.91.AND.ACFLTM(L,N).LT.ACFLTM(L,1)) THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ELSEIF (N.LE.90.AND.N.GT.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1))
1      THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ENDIF
30    CONTINUE
      CALL SCHDL(3,12400E+02,ATRI8)
      RETURN
      END

      SUBROUTINE MISSION
C      *****WHICH MISSION?
      COMMON/SCDM1/ATRI8(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNPUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSG(10),TURSU,HRSNO,EXPLY,SB
      X=SFAND(2)
      CUM=0
      P=1
      DO 25 J=1,NUMRTE
        IF (XX(49).EQ.0) CUM=CUM+FREQPC(J)
        IF (XX(49).EQ.1) CUM=CUM+FREQSG(J)
        IF (XX(49).EQ.2) CUM=CUM+FREQSU(J)
        IF (X.GE.CUM) P=P+1
25    CONTINUE
      ATRI8(1)=NBASE(P,0)
      ATRI8(9)=P
      RETURN
      END

      SUBROUTINE NEXT
C      *****NEXT LEG
      COMMON/SCDM1/ATRI8(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNPUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSG(10),TURSU,HRSNO,EXPLY,SB
      ATRI8(12)=ATRI8(11)+1
      ATRI8(13)=NBASE(ATRI8(9),ATRI8(13))
      ATRI8(14)=SAT(ATRI8(9),ATRI8(13))
      ATRI8(15)=STAGE(ATRI8(9),ATRI8(13))

```

```

    ATRIB(5)=1
    ATRIB(19)=SGT(ATRIB(9),ATRIB(17))
    XX(22)=NLEGS(ATRIB(9))
    RETURN
    END

```

```

SUBROUTINE STAGECR
C *****POSITION STAGE CREWS
COMMON/SCOM1/ATRIB(100),DB(100),DDL(100),STNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NFRNT,NNRUN,NMSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),BAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSG(10),TURSU,HRSMD,EXFLY,SB
DIMENSION NSET(40000)
COMMON OSET(40000)
EQUIVALENCE(NSET(1),OSET(1))
DIMENSION A(20),NNTOT(17)
DO 7 I=1,17
    NNTOT(I)=0
3 CONTINUE
DO 15 I=1,NUMRTE
    DO 20 J=1,NLEGS(I)-1
        IF (STAGE(I,J).EQ.1) THEN
            SB=NBASE(I,J)
            IF (XX(49).EQ.0) NNTOT(SB)=NNTOT(SB)+FREQPC(I)*(HRSMD/
1EXFLY)/XX(1)
            IF (XX(49).EQ.1) NNTOT(SB)=NNTOT(SB)+FREQSG(I)*(HRSMD/
1EXFLY)/XX(1)
            IF (XX(49).EQ.2) NNTOT(SB)=NNTOT(SB)+FREQSU(I)*(HRSMD/
1EXFLY)/XX(1)
            ENDIF
10 CONTINUE
15 CONTINUE
DO 25 K=1,17
    IF (XX(49).EQ.0) WRITE(NPRNT,100)NNTOT(K)
    IF (XX(49).EQ.1) WRITE(NPRNT,101)NNTOT(K)
    IF (XX(49).EQ.2) WRITE(NPRNT,102)NNTOT(K)
25 CONTINUE
DO 22 K=1,17
    IF (NNTOT(K).LT.NNGMIN) THEN
        CALL LINK(1,0)
        CALL LINK(7)
        GO TO 21
    ELSEIF (NNTOT(K).GT.NNGMAX) THEN
        IF (NNG(2).EQ.0) GO TO 22
        CALL RMVCR(1,2,A)
        A(2)=K
20 START MISSION FOR STAGE CREW ALLOWING FOR DEADHEAD & FEET
        A(3)=TNOW-UNFRM(5,15,2)-12
        CALL FILEM(K,3)
        NNTOT(K)=NNTOT(K)-1

```

```

        GO TO 21
    ENDIF
22  CONTINUE
100  FORMAT(' PEACE STAGE CREWS AT ',I2,', ',I2)
101  FORMAT(' SURGE STAGE CREWS AT ',I2,', ',I2)
102  FORMAT(' SUSTAINED STAGE CREWS AT ',I2,', ',I2)
    RETURN
    END

SUBROUTINE SURGE
C *****TRANSITION TO SURGE
COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMTE,BASIC(10),NLESS(10),FREOPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSS(10),TURSUS,HRCMO,EXPFY,SB
    XX(49)=1
    XX(53)=4
    XX(15)=USERF(4)
    XX(10)=12
    XX(11)=12
    XX(24)=.1680E+04
    XX(27)=XX(26)
    XX(40)=XX(30)
    XX(45)=XX(47)
    NCREW=(XX(9)+NACFT/4)*XX(7)
    DO 10 I=1,NCREW
        CALL ENTER(1,A)
10  CONTINUE
    XX(9)=XX(9)+NCREW
    CALL STAGEOP
    RETURN
    END

SUBROUTINE SUSTAIN
C *****TRANSITION TO SUSTAINED
COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMTE,BASIC(10),NLESS(10),FREOPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSS(10),TURSUS,HRCMO,EXPFY,SB
    XX(49)=0
    XX(53)=2
    XX(15)=USERF(4)
    XX(10)=6
    XX(11)=6
    XX(24)=.2760E+04
    XX(27)=XX(26)
    XX(40)=XX(30)
    XX(45)=XX(47)
    CALL STAGEOP

```

2/2

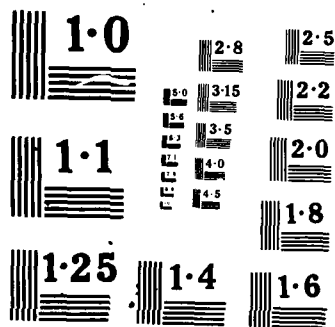
WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING

B L SUTTER DEC 85 AFIT/ENS/GOR/85D-19

F/G 5/9

NL

[illegible]



NATIONAL BUREAU OF S
MICROCOPY RESOLUT TEST

RETURN
END

C SUBROUTINE UPBRAV
*****CHANGE BRAVO CREW EVERY 48 HRS OR WHEN UTILIZED
COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON QSET(40000)
DIMENSION NSET(40000)
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION A(30)
ATRIB(18)=0.
NQ=NNQ(8)
IF (XX(52).NE.0.OR.NQ.EQ.0) GO TO 12
CALL ULINK(1,8)
CALL LINK(2)
12 XX(52)=0
NQ=NNQ(2)
IF (NQ.EQ.0.OR.NNACT(34).GE.1) GO TO 11
CALL ULINK(1,2)
IF (ATRIB(17).EQ.0) CALL LINK(8)
IF (ATRIB(17).NE.0) CALL LINK(10)
11 NRANK=NFIND(1,NCLNR,18,0,9.,0.0)
IF (NRANK.NE.0) CALL REMOVE(NRANK,NCLNR,A)
ATRIB(18)=9.
CALL SCHOL(9.,.4800E+02,ATRIB)
ATRIB(18)=0.
RETURN
END

C SUBROUTINE UPFLTM
*****UPDATE 90 AND 10 DAY TIME
COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/FL/ACFLTM(14),N1,MAN,N
IF (N.EQ.91) THEN
N90=1
ELSE
N90=N+1
ENDIF
IF (N.GE.31) THEN
N30=N-30
ELSE
N30=91+N-30
ENDIF
ATRIB(10)=ACFLTM(ATRIB(14),N1)+ATRIB(15)-ACFLTM(ATRIB(14),N90)
ATRIB(11)=ACFLTM(ATRIB(14),N1)+ATRIB(15)-ACFLTM(ATRIB(14),N30)
ACFLTM(ATRIB(14),N90)=ACFLTM(ATRIB(14),N)+ATRIB(15)
ATRIB(15)=0
XX(54)=ATRIB(11)
XX(55)=ATRIB(12)

RETURN
END

SUBROUTINE WARMUP

C *****REINITIATE STATISTICS AFTER WARMUP PERIOD
COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
I,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
XX(24)=.5000E+03
XX(27)=XX(26)
XX(40)=XX(30)
XX(45)=XX(43)
RETURN
END

SUBROUTINE WINDOW

C *****OK ALERT WINDOW IN ALL CREW QUEUES
COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
I,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON QSET(40000)
DIMENSION NSET(40000)
INTEGER RANK,Z
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION A(30), B(30)
RANK=1
I=4
Z=NNQ(I)
IF (RANK.GT.Z) GO TO 11
CALL COPY(RANK,I,A)
IF (TNOW-A(16).LE.XX(11)) GO TO 11
CALL PMOVE(RANK,I,A)
IF (I.EQ.4) THEN
XX(17)=XX(17)+1
TF=A(9)
NRANK=NFIND(1,5,P,0,TP,3,0)
CALL PMOVE(NRANK,6,B)
XX(51)=XX(51)+1
ENDIF
Z=Z-1
A(20)=1
CALL FILEM(P,4)
XX(55)=XX(55)+1
GO TO 2
11 IF (I.EQ.4) THEN
I=11
ELSE
I=I+1
ENDIF
IF (I.LE.17) THEN
Z=NNQ(I)
GO TO 2
ENDIF

RETURN
END

```

SUBROUTINE INTLC
C *****INITIALIZE
COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SET(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSG(10),TURSU,HRSMD,EXPFLY,SB
COMMON/FLY/ACFLTM(160,91),MAN,N
CHARACTER*6 BASE(10,0:10)
NUMRTE=0
WRITE(NPRNT,200)
200 FORMAT(' ROUTE DATA')
OPEN (UNIT=13, FILE='ROUTE.',STATUS='OLD')
REWIND(13)
READ(13,*)ROUTE
10 IF (ROUTE.LE.9999) THEN
    READ(13,*)BASIC(ROUTE),NLEGS(ROUTE),FREQPC(ROUTE)
    1,FREQSG(ROUTE),FREQSU(ROUTE)
    READ(13,201)(BASE(ROUTE,J), J=0,NLEGS(ROUTE))
201 FORMAT(11A6)
    READ(13,*)(STAGE(ROUTE,J),J=1,NLEGS(ROUTE))
    READ(13,*)(SET(ROUTE,J),J=1,NLEGS(ROUTE))
    READ(13,*)(SAT(ROUTE,J),J=1,NLEGS(ROUTE))
    WRITE(NPRNT,202)ROUTE,BASIC(ROUTE),NLEGS(ROUTE)
202 FORMAT(' ROUTE: ',F10.0,2X,'1 IF BASIC: ',F10.0,2X,'NUMBER OF
    1,LEGS: ',I2)
    WRITE(NPRNT,203)(FREQPC(ROUTE),FREQSG(ROUTE),FREQSU(ROUTE))
203 FORMAT(' PEACE USAGE: ',F5.2,2X,' SURGE USAGE: ',F5.2,2X,
    1,'SUSTAINED USAGE: ',F5.2)
    WRITE(NPRNT,204)(BASE(ROUTE,J),J=0,NLEGS(ROUTE))
204 FORMAT(' BASES: ',5X,11A6)
    WRITE(NPRNT,205)(STAGE(ROUTE,J),J=1,NLEGS(ROUTE))
205 FORMAT(' STAGE: ',9X,11F6.0)
    WRITE(NPRNT,206)(SET(ROUTE,J),J=1,NLEGS(ROUTE))
206 FORMAT(' SCHED END TIME: ',11F6.1)
    WRITE(NPRNT,207)(SAT(ROUTE,J),J=1,NLEGS(ROUTE))
207 FORMAT(' SCHED AIR TIME: ',11F6.2)
    NUMRTE=NUMRTE+1
    READ(13,*)ROUTE
    GO TO 10
ENDIF
READ(13,*)NACFT,TURPC,TURSG,TURSU
WRITE(NPRNT,207)NACFT,TURPC,TURSG,TURSU
207 FORMAT(' AIRCRAFT AT KCHS: ',I2,' PEACE TUR: ',F5.2,' SURGE TUR: ',
    1,F5.2,' SUSTAINED TUR: ',F5.2)
DO 25 ROUTE=1,NUMRTE
    DO 30 J=0,NLEGS(ROUTE)

```

```

      IF (BASE(ROUTE,J).EQ.'KCHS') NBASE(ROUTE,J)=10
      IF (BASE(ROUTE,J).EQ.'CYVR') NBASE(ROUTE,J)=11
      IF (BASE(ROUTE,J).EQ.'EGXX') NBASE(ROUTE,J)=12
      IF (BASE(ROUTE,J).EQ.'KPXX') NBASE(ROUTE,J)=13
      IF (BASE(ROUTE,J).EQ.'CYXX') NBASE(ROUTE,J)=14
      IF (BASE(ROUTE,J).EQ.'EDXX') NBASE(ROUTE,J)=15
      IF (BASE(ROUTE,J).EQ.'ENXX') NBASE(ROUTE,J)=16
      IF (BASE(ROUTE,J).EQ.'XTIK') NBASE(ROUTE,J)=17
20      CONTINUE
25      CONTINUE
C      PEACETIME CREW REST POLICY
      XX(53)=2
      XX(47)=60*24/NACFT
      XX(48)=547.92*24/NACFT
      XX(50)=1095.84*24/NACFT
      XX(29)=NACFT
      XX(18)=NACFT
      N=91
      DO 40 I=1,160
        ACFLTM(I,91)=UNFRM(25.,330.,2)
        RC=ACFLTM(I,91)
        IF (RC.GE.125.) THEN
          QC=UNFRM(0.,125.,3)
          ACFLTM(I,61)=RC-QC
        ELSEIF (RC.LT.125.) THEN
          ACFLTM(I,61)=UNFRM(0.,RC,2)
        ENDIF
        SC=ACFLTM(I,61)
        DO 50 K=62,90
          ACFLTM(I,K)=ACFLTM(I,K-1)+(RC-SC)/29
        CONTINUE
        ACFLTM(I,1)=0
        DO 20 K=2,60
          ACFLTM(I,K)=ACFLTM(I,K-1)+ACFLTM(I,61)/59
        CONTINUE
      CONTINUE
40      CONTINUE
C      MISSION FREQUENCY
      XX(15)=USERF/41
      ATRIB(18)=0.
      CALL SCHDL(7.,0400E+02,ATRIB)
      CALL SCHDL(7.,1191E+04,ATRIB)
      ATRIB(18)=9.
      CALL SCHDL(9.,4900E+02,ATRIB)
      ATRIB(18)=0.
      CALL SCHDL(9.,0100E+02,ATRIB)
      CALL SCHDL(9.,0751E+04,ATRIB)
      CALL SCHDL(11.,5000E+03,ATRIB)
      RETURN
      END

```

```

SUBROUTINE DTPUT
C *****OUTPUT
COMMON/SCDM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREGSU(90),FREGSG(10),TURSU,HRSMD,EXPLY,SB
COMMON/FLY/ACFLTM(160,91),MAN,N
WRITE(NPRNT,102),XX(1)
102 FORMAT(' STAGE CREW FOR EVERY ',F3.0,' ARRIVALS')
WRITE(NPRNT,103),XX(2),XX(3)
103 FORMAT(' 70 & 90 DAY LIMITS: ',2F4.0)
WRITE(NPRNT,104),XX(9)
104 FORMAT(' * CREWS AVAILABLE: ',F4.0)
WRITE(NPRNT,105),XX(4),XX(5),XX(6)
105 FORMAT(' RELIABILITY FACTORS: ',F5.1,2X,F5.1,2X,F5.1)
RETURN
END

FUNCTION USERF(1FN)
C *****USER FUNCTIONS
COMMON/SCDM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREGSU(10),FREGSG(10),TURSU,HRSMD,EXPLY,SB
COMMON/FLY/ACFLTM(160,91),MAN,N
DIMENSION VAL(10)
DO 10 I=1,4,5) IFN
COMPUTE SCHED FLY TIME
1 RETURN
C *****COMPUTE HOME STATION CREW REST
IF (DTNOW-ATTRIB(9))>LT.75) USERF=12
IF (DTNOW-ATTRIB(9))>LE.215) USERF=(DTNOW-ATTRIB(9))/2
IF (DTNOW-ATTRIB(9))>ET.215) USERF=72
RETURN
C *****HOME STATION ESTIMATED UNSCHED MAINTENANCE
USERF=RNORM(5,2,3)
RETURN
EXPLY=0
C *****COMPUTE SCHEDULING FREQUENCY FOR TARGET UTS RATE
HRS PER MO. / EXP FLY TIME = #MNS PER MO.
730.65 HRS IN A MO. / MNS PER MO. = FREQUENCY
IF (XX(49).EQ.0) HRSMD=NACFT*TURPC*30.44
IF (XX(49).EQ.1) HRSMD=NACFT*TURSG*30.44
IF (XX(49).EQ.2) HRSMD=NACFT*TURSU*30.44
DO 15 I=1,NUMRTE
VAL(I)=0
DO 20 J=1,NLESS(I)
VAL(I)=VAL(I)+SAT(I,J)
20 CONTINUE

```

```

      IF (XX(49).EQ.0) EXPFLY=EXPFLY+(FREOPC(I)*VAL(I))
      IF (XX(49).EQ.1) EXPFLY=EXPFLY+(FREDSG(I)*VAL(I))
      IF (XX(49).EQ.2) EXPFLY=EXPFLY+(FREDSU(I)*VAL(I))
15    CONTINUE
      USERF=730.56/(HRSMO/EXPFLY)
      RETURN
C     *****IS BASE STAGING LOCATION?
5     USERF=STAGE(ATTRIB(9),ATTRIB(13)-1)
      RETURN
5     USERF=0
      RETURN
      END

```

Appendix D

Scenario Files

This appendix contains the scenario data files used for both single homebase models and the multiple homebase model. See Appendix H for scenario information.

"Route" for NATO Single Base

```
1
1 3 .22 0.0 .16
KCHS KPXX EGXX KCHS
0 1 1
2.1 2.1 2.1
0.83 7.72 8.87

2
1 5 .78 .39 .53
KCHS KPXX CYXX EDXX EGXX KCHS
0 1 0 1 1
2.1 2.1 2.1 2.1 2.1
0.83 3.23 5.52 1.21 8.87

3
1 5 0.0 .08 0.0
KCHS KPXX CYXX ENXX EGXX KCHS
0 1 0 1 1
2.1 2.1 2.1 2.1 2.1
0.83 3.23 5.07 2.64 8.87

4
1 3 0.0 .53 .71
KCHS PTIK CYXR EDXX EGXX KCHS
0 1 0 1 1
2.1 2.1 2.1 2.1 2.1
2.83 4.70 5.51 1.21 7.61

#####
10 4.3 16.1 14.4
```

"Route1" for NATO Multi-homebase

1 3 .11 0.0 .08
KCHS KPXX EGXX KCHS
0 1 1
2.3 2.3 2.3
0.83 7.72 8.87

2
1 5 .39 .20 .26
KCHS KPXX DYXX EDXX EGXX KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
0.83 3.27 5.51 1.21 8.87

3
1 5 0.0 .04 0.0
KCHS KPXX DYXX ENXX EGXX KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
0.83 3.27 5.07 2.64 8.87

4
1 5 0.0 .257 .16
KCHS KPXX DYXX EDXX EGXX KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
2.88 4.70 5.51 1.21 7.71

5
1 5 .5 .177 .07
KCHS KPXX DYXX EDXX EGXX KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3

6
1 5 0.0 .70 .02
KCHS KPXX DYXX EDXX EGXX KCHS
0 1 0 1 1
2.3 2.3 2.3 2.3 2.3
3.11 4.7 5.51 1.21 7.72

00000000
20 3.3 15.1 17.4

"Route2" for SWA Single Homepage

1
1 7 1.0 .184 .105
KWRI KDOV LPLA HEXX OQXX OEXX LPLA KWRI
0 1 1 0 1 1 1
2.1 2.1 2.1 2.1 2.1 2.1 2.1
0.83 5.00 6.67 3.50 2.67 9.14 5.69

2
1 7 0.0 .395 .895
KWRI KTIK LPLA HEXX OQXX OEXX LPLA KWRI
0 1 1 0 1 1 1
2.1 2.1 2.1 2.1 2.1 2.1 2.1
3.11 7.06 6.67 3.50 2.67 9.14 5.69

3
1 7 0.0 .421 0.0
KWRI KPXX LPLA HEXX OQXX OEXX LPLA KWRI
0 1 1 0 1 1 1
2.1 2.1 2.1 2.1 2.1 2.1 2.1
1.24 5.43 6.67 3.50 2.67 9.14 5.69

99999999
30 4.0 15.6 13.9

Appendix E

Simulation Output

ROUTE DATA

PEACE USAGE: 0.220 SURGE USAGE: 0.000 SUSTAINED USAGE: 0.160

BASES: KCHS KPXX EGXX KCHS

STAGE? 0. 1. 1.

SCHED GND TIME: 2.1 2.1 2.1

SCHED AIR TIME: 0.87 7.72 8.87

PEACE USAGE: 0.780 SURGE USAGE: 0.190 SUSTAINED USAGE: 0.530

BASES: KCHS KPXX CYXX EDXX EGXX KCHS

STAGE? 0. 1. 0. 1. 1.

SCHED GND TIME: 2.1 2.1 2.1 2.1 2.1

SCHED AIR TIME: 0.87 3.23 5.52 1.21 3.87

PEACE USAGE: 0.000 SURGE USAGE: 0.000 SUSTAINED USAGE: 0.000

BASES: KCHS KPXX CYXX ENXX EGXX KCHS

STAGE? 0. 1. 0. 1. 1.

SCHED GND TIME: 2.1 2.1 2.1 2.1 2.1

SCHED AIR TIME: 0.87 3.23 5.07 2.64 8.87

PEACE USAGE: 0.000 SURGE USAGE: 0.530 SUSTAINED USAGE: 0.310

BASES: KCHS KTIK CYXF EDXX EGXX KCHS

STAGE? 0. 1. 0. 1. 1.

SCHED GND TIME: 2.1 2.1 2.1 2.1 2.1

SCHED AIR TIME: 2.55 4.30 5.51 1.21 7.91

AIRCRAFT AT KCHS: 20 PEACE TUR: 7.50 SURGE TUR: 15.10 SUSTAINED TUR: 17.40

SUSTAINED STAGE CREWS AT 11: 0

SUSTAINED STAGE CREWS AT 12: 9

SUSTAINED STAGE CREWS AT 13: 0

SUSTAINED STAGE CREWS AT 14: 10

SUSTAINED STAGE CREWS AT 15: 0

SUSTAINED STAGE CREWS AT 16: 0

SUSTAINED STAGE CREWS AT 17: 0

S L A M S U M M A R Y R E P O R T

SIMULATION PROJECT THEBIS2

BY BEUTTER

DATE 2/14/1985

RUN NUMBER 1 OF 1

CURRENT TIME 0.2761E+04

STATISTICAL ARRAYS CLEARED AT TIME 0.6000E+01

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO. OF OBS
DUTY DAY	0.108E+02	0.171E+01	0.159E+00	0.275E+01	0.181E+02	1743
INTER AT CYXR	0.310E+01	0.273E+01	0.882E+00	0.586E-02	0.156E+02	739
INTER AT EGXX	0.249E+01	0.249E+01	0.100E+01	0.549E-02	0.159E+02	868
INTER AT KPXX			NO VALUES RECORDED			
INTER AT DYXX	0.459E+01	0.367E+01	0.800E+00	0.403E-01	0.275E+02	472
INTER AT EDXX			NO VALUES RECORDED			
INTER AT ENXX			NO VALUES RECORDED			
INTER AT KTIK			NO VALUES RECORDED			
MISSION LENGTH	0.102E+03	0.349E+02	0.342E+00	0.327E+02	0.262E+03	864
LAST DUTY DAY	0.107E+02	0.833E+00	0.778E-01	0.914E+01	0.158E+02	864
BYS FLY TIME	0.520E+04	0.375E+04	0.721E+00	0.196E+02	0.129E+05	864
MISSION LENGTH	0.817E+02	0.000E+00	0.000E+00	0.817E+02	0.817E+02	1
BYS FLY TIME	0.818E+04	0.000E+00	0.000E+00	0.818E+04	0.818E+04	1

STATISTICS FOR TIME-PERSISTENT VARIABLES

	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	TIME INTERVAL	CURRENT VALUE
CREWS AT HOME	32.231	14.708	12.00	50.00	2161.000	14.00
CREWS AT CYXR	2.095	2.732	0.00	11.00	2161.000	4.00
CREWS AT EGXX	6.125	6.536	0.00	23.00	2161.000	7.00
CREWS AT DYXX	3.338	3.404	0.00	13.00	2161.000	2.00
MISSIONS CANCEL	0.000	0.000	0.00	0.00	2161.000	0.00
BURNOUT	449.820	327.824	92.00	1168.00	2161.000	1168.00
# ACFT RMC	21.307	3.423	9.00	29.00	2161.000	18.00

FILE STATISTICS

FILE NUMBER	ASSOCIATED MODE TYPE	AVERAGE LENGTH	STANDARD DEVIATION	MAXIMUM LENGTH	CURRENT LENGTH	AVERAGE WAIT TIME
1	AWAIT	0.001	0.028	1	0	0.035
2	QUEUE	32.231	14.708	50	0	70.855
3	QUEUE	0.000	0.000	1	0	0.000
4	AWAIT	0.007	0.086	2	0	0.018
5	QUEUE	0.000	0.000	1	0	0.000
6	QUEUE	5.291	2.831	15	9	12.647
7	QUEUE	0.000	0.000	0	0	0.000
8	QUEUE	0.750	0.433	1	1	33.082
9	QUEUE	0.000	0.000	0	0	0.000
10	QUEUE	0.000	0.000	0	0	0.000
11	QUEUE	2.095	2.732	11	4	8.575
12	QUEUE	6.125	6.536	23	7	9.180
13	QUEUE	0.000	0.000	1	0	0.000
14	QUEUE	3.338	3.404	13	2	8.597
15	QUEUE	0.000	0.000	1	0	0.000

16	QUEUE	0.000	0.000	0	0	0.000
17	QUEUE	0.000	0.000	1	0	0.000
18		0.000	0.000	0	0	0.000
19		0.000	0.000	0	0	0.000
20		0.000	0.000	0	0	0.000
21	QUEUE	0.035	0.278	4	0	0.216
22	QUEUE	0.069	0.334	6	0	0.167
23	QUEUE	0.056	0.231	1	0	13.549
24	QUEUE	0.044	0.239	3	0	0.196
25	QUEUE	0.050	0.219	1	0	13.598
26	QUEUE	0.000	0.000	0	0	0.000
27	QUEUE	0.031	0.174	1	0	17.461
28		0.000	0.000	0	0	0.000
29	CALENDAR	53.058	17.809	104	96	1.586

REGULAR ACTIVITY STATISTICS

ACTIVITY INDEX	AVERAGE UTILIZATION	STANDARD DEVIATION	MAXIMUM UTILIZATION	CURRENT UTILIZATION	ENTITY COUNT
1	4.8786	2.6588	14	8	875
2	0.0000	0.0000	1	0	1680
3	0.8009	0.8102	5	1	804
4	1.4753	1.3392	8	3	1638
5	8.4767	4.5911	21	12	4225
6	0.0840	0.2936	2	0	18
7	0.0258	0.1585	1	0	6
8	1.7877	1.4672	9	2	1681
9	0.0224	0.1479	1	0	6
10	0.0000	0.0000	1	0	1169
11	0.0000	0.0000	1	0	289
12	0.0000	0.0000	1	0	45
13	0.0000	0.0000	0	0	0
14	0.0122	0.1096	1	0	1
15	0.0000	0.0000	1	0	851
16	0.0000	0.0000	1	0	1742
17	0.0000	0.0000	1	0	4271
18	0.0000	0.0000	1	0	5
19	0.0000	0.0000	1	0	1
20	0.1179	0.3417	2	0	40
21	0.0360	0.5111	3	0	80
22	0.0268	0.1725	2	1	45
23	0.0627	0.4799	1	0	3
24	0.4245	0.4943	1	0	2
25	0.8047	1.7143	6	6	105
26	0.0000	0.0000	0	0	0

RESOURCE STATISTICS

RESOURCE NUMBER	RESOURCE LABEL	CURRENT CAPACITY	AVERAGE UTIL	STANDARD DEVIATION	MAXIMUM UTIL	CURRENT UTIL
1	ACFT	30	18.62	7.551	30	26

RESOURCE NUMBER	RESOURCE LABEL	CURRENT AVAILABLE	AVERAGE AVAILABLE	MINIMUM AVAILABLE	MAXIMUM AVAILABLE
1	ACFT	4	11.3783	0	22

TIME-PERSISTENT HISTOGRAM NUMBER 1
CREWS AT HOME

CELL TIME	RELA FREQ	UPPER CELL LIM	0	20	40	60	80	100
			+	+	+	+	+	+
0.	0.00	0.000E+00	+					+
0.	0.00	0.500E+01	+					+
0.	0.00	0.100E+02	+					+
147.	0.07	0.150E+02	****					+
849.	0.79	0.200E+02	*****			C		+
65.	0.03	0.250E+02	***			C		+
22.	0.01	0.300E+02	**			C		+
1.	0.00	0.350E+02	+			C		+
0.	0.00	0.400E+02	+			C		+
315.	0.10	0.450E+02	*****				C	+
868.	0.40	0.500E+02	*****					C
0.	0.00	0.550E+02	+					C
0.	0.00	0.600E+02	+					C
0.	0.00	0.650E+02	+					C
0.	0.00	0.700E+02	+					C
0.	0.00	0.750E+02	+					C
0.	0.00	0.800E+02	+					C
0.	0.00	0.850E+02	+					C
0.	0.00	0.900E+02	+					C
0.	0.00	0.950E+02	+					C
0.	0.00	0.100E+03	+					C
0.	0.00	INF	+					C
---			+	+	+	+	+	+
***			0	20	40	60	80	100

STATISTICS FOR TIME-PERSISTENT VARIABLES

	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	TIME INTERVAL	CURRENT VALUE
CREWS AT HOME	32.231	14.708	12.00	50.00	2161.000	14.00

```

**TABLE NUMBER 1**
FUN NUMBER 1

```

TIMEHRS	AUR	AVG WORK MONTH	AVG FLY HRSMO	AVG TIME AWAYMO
0.1800E+04	0.5047E+01	0.1216E+03	0.4797E+02	0.2792E+03
0.1920E+04	0.7197E+01	0.1353E+03	0.6888E+02	0.4222E+03
0.2040E+04	0.8292E+01	0.1414E+03	0.7917E+02	0.4651E+03
0.2160E+04	0.8545E+01	0.1421E+03	0.8144E+02	0.4742E+03
0.2280E+04	0.9088E+01	0.1450E+03	0.8652E+02	0.4923E+03
0.2400E+04	0.9159E+01	0.1454E+03	0.8725E+02	0.4907E+03
0.2520E+04	0.9413E+01	0.1465E+03	0.8946E+02	0.4975E+03
0.2640E+04	0.9499E+01	0.1472E+03	0.9047E+02	0.5011E+03
0.2760E+04	0.9567E+01	0.1476E+03	0.9118E+02	0.5003E+03
MINIMUM	0.5047E+01	0.1216E+03	0.4797E+02	0.2792E+03
MAXIMUM	0.9567E+01	0.1476E+03	0.9118E+02	0.5011E+03

```

**PLOT NUMBER 1**
  RUN NUMBER 1

```

						SCALES OF PLOT						
U=AUR	0.505E+01					0.731E+01						0.957E+01
W=AVG WORK MONO.	1.122E+03					0.175E+03						0.148E+03
F=AVG FLY HRSMO.	4.805E+02					0.495E+02						0.812E+02
T=AVG TIME AWAQ.	0.279E+02					0.190E+02						0.501E+02
	0	10	20	30	40	50	60	70	80	90	100	DUPS
TIMEHRS												
0.18X05+04	+					+						+ UW UF
0.18205+04	+					U+W		T				+ UF
0.20415+04	+					+			U W		T	+ UF
0.21605+04	+					+					T	+ UW UF
0.22805+04	+					+					U T	+ UW UF
0.24005+04	+					+					UW T	+ UF
0.25205+04	+					+						UT+ UW UF
0.26405+04	+					+						UT UW UF
0.27605+04	+					+						U UW UF
	0	10	20	30	40	50	60	70	80	90	100	DUPS
TIMEHRS												

Multi-Base SLAM Network Code

F-1

```

START ASSIGN, ATRIB(5)=1, ATRIB(11)=10, ATRIB(14)=1, ATRIB(9)=0,
      ATRIB(7)=0, ATRIB(10)=10, ATRIB(17)=0;      INIT BASIC CREW, PRESENT PAGE.
ASSIGN, XX(14)=NNG(10), 1;
ACT/20, 10, XX(14).GE.1.AND.ATRIB(11)+20.GE.XX(2), START;      APP 30 DAY LMT
ACT/22, 10, XX(14).GE.1.AND.ATRIB(12)+20.GE.XX(3), START;      APP 90 DAY LMT
ACT;
EVENT, 13, 1;      SPLIT BASES*
ACT/20, 24, ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3), RET;      ENTER 24 HOUR
      CREW REST IF 30 OR 90 DAY LIMIT EXCEEDED
;
RET EVENT, 10, 1;      UPDATE 30/90 FLY TIME
ACT,,, START;
QUEUE(72);
GOON, 1;
ACT/34, 10, ATRIB(1).EQ.20, QUIT;
ACT/35, 12;
QUEB QUEUE(8);      BRAVO CREW FILE
QUIT QUEUE(10);      BRAVO CREW FILE*
QUE2 QUEUE(12),,,, MAT1;      AWAIT MISSION
;*****CREATE MISSION*****
;*****
      CREATE, RNDPM(XX(15), 1, 3), 0;      CREATE MISSION AT FREQ OF XX(15)
MSN EVENT, 4, 1;      DETERMINE MISSION
      A63750; ATRIB(3)=0, ATRIB(4)=1, ATRIB(5)=1;      INTLC COUNTRIES GREENS
;      ASSIGN, XX(16)=NNRSC(ACFT)+XX(17);      16FMAN0000CRAFTCRAFTVAINBOUND
      ASSIGN, XX(57)=NNRSC(BACFT)+XX(58);
      EDCN, 1;
      ACT,, XX(59).LE.0.AND.XX(59).EQ.10, ACIA;      CANCEL DUE TO NO ACFT*
      ACT,, XX(57).LE.0.AND.XX(59).EQ.20, ACIA;      BACFT*
      ACT,, XX(59).GT.0.AND.XX(59).EQ.10, EPI;
      ACT;
      ASSIGN, XX(59)=XX(59)+1;
      ACT,,, QUIT;
UP1 ASSIGN, XX(17)=XX(17)+1;      ONE ACFT BROKEN FOR
QUIT ASSIGN, ATRIB(16)=TNOW;
QUE2 QUEUE(12),,,, MAT1;      MISSION QUEUE
MAT1 MATCH, 1, QUE2 FEET, QUEUE(6);      MATCH CREW WITH MISSION*
QUE ASSIGN, 11=ATRIB(9);
ACT,,, QUE6;
;*****
;      *****CREW REST*****
;*****
FEET EDCN;
      ASSIGN, ATRIB(9)=11, ATRIB(17)=0, ATRIB(10)=0;      MISSION NUMBER, FLY TIME
;      TIME AWAY INIT=0
      ACT/1, 12,,,      CREW REST
      ASSIGN, ATRIB(16)=TNOW;
      GOON, 1;
      ACT,, ATRIB(1).EQ.20, AW31;
      ACT;
      AWAIT(4), ACFT;
      ASSIGN, XX(17)=XX(17)+1;      RESETS AWAIL OR PROJECTED ACFT

```

```

600N;
ACT,1,,QUE5;                                TRAVEL;
AW31 AWAIT(31),BACFT;                          ;
ASSIGN,XX(58)=XX(58)+1;                        ;
600N;                                          ;
ACT,1;                                          ;
;*****
;                                     ****CREW SHOWS AT SODN****
;*****
QUE5  QUEUE(5),,,,MAT2;                        CREW
;
;                                     ****PREFLIGHT****
;                                     ****
QUE5  QUEUE(6),,,,MAT2;                        MISSION
MAT2  MATCH,2,QUE5/ACC,QUE5/ACC;
ACC   ACCUM,2,2,LAST;          ATTACHES MSN TO CREW. RETAINS MSN ATTRIB
ASSIGN,ATTRIB(17)=0,ATTRIB(6)=TNOW,ATTRIB(8)=TNOW;    LEG NUMBER INIT=0
ASSIGN,XX(18)=XX(18)-1;
600N,1;
ACT,EXPON(2,2,3),ATTRIB(17).NE.0,FLY1;          BRAVO CREW FLYING
ACT/22;
ASSIGN,XX(19)=XX(10)-2;
600N,1;
ACT/3,UNFRM(2,0,2,3,3),XX(4),FLY;              ON TIME
ACT/27,UNFRM(2,3,XX(10),2),XX(5),FLY;          PREFLIGHT : MAX RAMP
ACT/7,TRIAB(XX(19),XX(10),XX(10),3),XX(6),ACL;  RAMP EXCEEDED. RESCHEDULE
;*****
;                                     ****FLY****
;*****
FLY1  ASSIGN,ATTRIB(17)=0;                      BRAVO UTILIZED
FLY   600N,1;
EVENT,5,1;          COMPUTE NEXT LEG & FLY TIME
600N,1;
ACT,19,,TNOW+ATTRIB(17)-ATTRIB(6),37,16,MEDH;
;                                     WILL EXCEED DUTY DAY ON NEXT LEG
;
ACT/24,;;
ASSIGN,XX(19)=ATTRIB(17)-.5,XX(20)=ATTRIB(17)+1;
ASSIGN,XX(21)=TRIAB,XX(19),ATTRIB(17),XX(20),4;
ASSIGN,ATTRIB(15)=ATTRIB(15)+XX(21);
ASSIGN,ATTRIB(17)=ATTRIB(17)+XX(21);          ACCUM FLY TIME
ASSIGN,XX(19)=XX(19)+1;
600N,1;
ACT/5,XX(21),ATTRIB(17),EG,ATTRIB(20),HOME;    NEXT HOME
ACT/5,XX(21);
ASSIGN,XX(19)=XX(19)-1;
ASSIGN,XX(22)=TNOW-XX(24),XX(25)=XX(26)-XX(27);
ASSIGN,XX(28)=XX(29)*XX(27)/24,XX(29)=XX(25)/XX(19)+ATTRIB(17),XX(29);
;                                     COMPUTE ACHIEVED UTE RATE

```

```

:*****
:
:*****ENROUTE STOPS*****
:*****
      GCON,1;
      ACT/2,,ATRIB(4).EQ.1,,STAGE;                STAGE CREW
      ACT;
      GCON;
      ASSIGN,ATRIB(1)=ATRIB(2);
      ACT/8,RNORM(2.3,,15.2),,FLY;                SCHEDULED GND TIME
MECH GCON;                DUTY DAY EXCEEDED-MECHANICAL STAGE
      ASSIGN,ATRIB(2)=ATRIB(1),ATRIB(12)=ATRIB(12)-1;
      ACT,,STAGE;

:
:
:                STAGE
STAGE GCON;
      ASSIGN,XY(20)=XY(20)+TNDW-ATRIB(6);          ACCUM. DUTY TIME
      EVENT,10,1;
      COLCT,INT(5),DUTY DAY,,1;
      ACT/26,,ATRIB(2).EQ.10,OF,ATRIB(2).EQ.20,XOLD;HOME STA DUTY DAY EXCEEDED;
      ACT,,ATRIB(2).EQ.11,CYR;                WHICH BASE?
      ACT,,ATRIB(2).EQ.12,ESXX;
      ACT,,ATRIB(2).EQ.13,KPXX;
      ACT,,ATRIB(2).EQ.14,CYXX;
      ACT,,ATRIB(2).EQ.15,EDXX;
      ACT,,ATRIB(2).EQ.16,ENXX;
      ACT,,ATRIB(2).EQ.17,XTIK;
      ACT,,ATRIB(2).EQ.18,XDDV;
      CREATE(1,0,1,1,DUMMY TO INIT QUEUE(9))
      ACT;
GUSEF QUEUE(9);                CYCLE IF ALERT WINDOW EXCEEDED
      ACT;
      GCON,1;
      ACT,,ATRIB(2).EQ.10,OF,ATRIB(2).EQ.20,QUE2;
      ACT,,ATRIB(2).EQ.11,CY;
      ACT,,ATRIB(2).EQ.12,ES;
      ACT,,ATRIB(2).EQ.13,KP;
      ACT,,ATRIB(2).EQ.14,CYX;
      ACT,,ATRIB(2).EQ.15,ED;
      ACT,,ATRIB(2).EQ.16,EN;
      ACT,,ATRIB(2).EQ.17,KT;
      ACT,,ATRIB(2).EQ.18,XD;
      ACT;
      TERM;

:*****
:
:*****STAGE BASE SUBPROGRAMS*****
:*****
:                CYR STAGE
CYR GCON,1;
      ACT,,ATRIB(2).EQ.ATRIB(2),ME11;          ARRIVAL DUE TO MECH STAGE
      ACT;
      COLCT,SET,INTER AT CYR,,1;                INTERARRIVAL

```

```

ME11  GOON,2;
      ACT,,,0111;
      ACT;
      GOON,1;
      ACT/21,RNDNM(24,,3,,3),ATTRIB(11).GE.XX(2).OR.ATTRIB(12).GE.XX(3),DEAD;
      ;                                CHECK 30/90 TIME & DEADHEAD
      ACT;
CY     GOON;
      ACT,UNFRM(13,,14,,3);                                CREW REST
      ASSIGN,ATTRIB(16)=TNOW;
      ACT,,,0112;
0111  QUEUE(21),,,,MAT3;                                ACFT
0112  QUEUE(11),,,,MAT3;                                CREWS AVAIL
MAT3  MATCH,5,0111/AX1,0112/AC1;                                MATCH ACFT WITH CREW
AX1   ASSIGN,XX(31)=ATTRIB(1),XX(32)=ATTRIB(2),XX(33)=ATTRIB(3),
      XX(34)=ATTRIB(4),XX(35)=ATTRIB(9),XX(36)=ATTRIB(13),
      XX(37)=ATTRIB(19);
AC1   ACCUM,2,2,LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37);
      ACT,,,CONT;
      ;
      ;                                EGXX STAGE
ESXX  GOON,1;
      ACT,,ATTRIB(1).EQ.ATTRIB(2),ME12;
      ACT;
      COLCT,BET,INTER AT ESXX,,1;
ME12  GOON,2;
      ACT,,,0121;
      ACT;
      GOON,1;
      ACT/21,RNDNM(24,,3,,3),ATTRIB(11).GE.XX(2).OR.ATTRIB(12).GE.XX(3),DEAD;
      ACT;
EG     GOON;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATTRIB(16)=TNOW;
      ACT,,,0122;
0121  QUEUE(22),,,,MAT4; ACFT
0122  QUEUE(12),,,,MAT4; CREWS AVAIL
MAT4  MATCH,5,0121/AX2,0122/AC2;
AX2   ASSIGN,XX(31)=ATTRIB(1),XX(32)=ATTRIB(2),XX(33)=ATTRIB(3),
      XX(34)=ATTRIB(4),XX(35)=ATTRIB(9),XX(36)=ATTRIB(13),
      XX(37)=ATTRIB(19);
AC2   ACCUM,2,2,LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37);
      ACT,,,CONT;
      ;
      ;                                KPXX STAGE

```

```

KFXX 500N,1;
      ACT,,ATTRIB(1).EQ.ATTRIB(2).ME13;
      ACT;
      COLCT,BET,INTER AT KFXX,,1;
ME13 500N,2;
      ACT,,Q131;
      ACT;
      600N,1;
      ACT/21,RNORM(24,,3,,3),ATTRIB(11).GE.XX(2).OR.ATTRIB(12).GE.XX(3),DEAD;
      ACT;
KP 600N;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATTRIB(16)=TNOW;CIB
      ACT,,Q132;
Q131 QUEUE(23),,,,MATS; ACFT
Q132 QUEUE(17),,,,MATS; CREWS AVAIL W/2
MATS MATCH,S,Q131/AX3,Q132/AC3;
AX3 ASSIGN,XX(31)=ATTRIB(1),XX(32)=ATTRIB(2),XX(33)=ATTRIB(3),
      XX(34)=ATTRIB(4),XX(35)=ATTRIB(9),XX(36)=ATTRIB(13),
      XX(37)=ATTRIB(19);
AC3 ACCUM,2,2,LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37);
      ACT,,CONT;
:
:
CYXX STAGE
CYXX 500N,1;
      ACT,,ATTRIB(1).EQ.ATTRIB(2).ME14;
      ACT;
      COLCT,BET,INTER AT CYXX,,1;
ME14 500N,2;
      ACT,,Q141;
      ACT;
      600N,1;
      ACT/21,RNORM(24,,3,,3),ATTRIB(11).GE.XX(2).OR.ATTRIB(12).GE.XX(3),DEAD;
      ACT;
CYX 600N;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATTRIB(16)=TNOW;
      ACT,,Q142;
Q141 QUEUE(24),,,,MAT6; ACFT
Q142 QUEUE(14),,,,MATS; CREWS AVAIL
MATS MATCH,S,Q141/AX4,Q142/AC4;
AX4 ASSIGN,XX(31)=ATTRIB(1),XX(32)=ATTRIB(2),XX(33)=ATTRIB(3),
      XX(34)=ATTRIB(4),XX(35)=ATTRIB(9),XX(36)=ATTRIB(13),
      XX(37)=ATTRIB(19);
AC4 ACCUM,2,2,LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37);

```

```

      ACT,,,CONT;
;
EDXX                                     EDXX STAGE
EDXX  GOON,1;
      ACT,,ATRIB(1).EQ.ATRIB(2),ME15;
      ACT;
      COLCT,BET,INTER AT EDXX,,1;
ME15  GOON,2;
      ACT,,,Q151;
      ACT;
      GOON,1;
      ACT/21,RNORM(24,,3,,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
      ACT;
ED    GOON;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATRIB(16)=TNOW;
      ACT,,,Q152;
Q151  QUEUE(25),,,,MAT7; ACFT
Q152  QUEUE(15),,,,MAT7; CREWS AVAIL
MAT7  MATCH,5,Q151/AX5,Q152/AC5;
AX5   ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
      XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
      XX(37)=ATRIB(19);
ACS   ACCUM,2,2,LAST;
      ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),
      ATRIB(4)=XX(34),ATRIB(9)=XX(35),ATRIB(13)=XX(36),
      ATRIB(19)=XX(37);
      ACT,,,CONT;
;
;
ENXX                                     ENXX STAGE
ENXX  GOON,1;
      ACT,,ATRIB(1).EQ.ATRIB(2),ME16;
      ACT;
      COLCT,BET,INTER AT ENXX,,1;
ME16  GOON,2;
      ACT,,,Q161;
      ACT;
      GOON,1;
      ACT/21,RNORM(24,,3,,3),ATRIB(11).GE.XX(2).OR.ATRIB(12).GE.XX(3),DEAD;
      ACT;
EN    GOON;
      ACT,UNFRM(13,,14,,3);
      ASSIGN,ATRIB(16)=TNOW;
      ACT,,,Q162;
Q161  QUEUE(26),,,,MAT8; ACFT
Q162  QUEUE(16),,,,MAT8; CREWS AVAIL
MAT8  MATCH,5,Q161/AX6,Q162/AC6;
AX6   ASSIGN,XX(31)=ATRIB(1),XX(32)=ATRIB(2),XX(33)=ATRIB(3),
      XX(34)=ATRIB(4),XX(35)=ATRIB(9),XX(36)=ATRIB(13),
      XX(37)=ATRIB(19);
ACS   ACCUM,2,2,LAST;
      ASSIGN,ATRIB(1)=XX(31),ATRIB(2)=XX(32),ATRIB(3)=XX(33),

```

```

        ATRIB(4)=XX(34), ATRIB(9)=XX(35)=XX(36),
        ATRIB(19)=XX(37);
        ACT,,,CONT;

;
;
        KTIK STAGE
KTIK  GOON,1;
      ACT,, ATRIB(1).EQ. ATRIB(2), ME17;
      ACT;
      COLCT, BET, INTER AT KTIK,,1;
ME17  GOON,2;
      ACT,,,Q171;
      ACT;
      GOON,1;
      ACT/21, RNORM(24,,3,,3), ATRIB(11).GE. XX(2).OR. ATRIB(12).GE. XX(3), DEAD;
      ACT;
KT     GOON;
      ACT, UNFRM(13,,14,,3);
      ASSIGN, ATRIB(16)=TNOW;
      ACT,,,Q172;
Q171  QUEUE(27),,,,MAT9; ACFT
Q172  QUEUE(17),,,,MAT9; CREWS AVAIL
MAT9  MATCH,5,Q171/AX7,Q172/AC7;
AX7   ASSIGN, XX(31)=ATRIB(1), XX(32)=ATRIB(2), XX(33)=ATRIB(3),
      XX(34)=ATRIB(4), XX(35)=ATRIB(9), XX(36)=ATRIB(13),
      XX(37)=ATRIB(19);
AC7   ACCUM,2,2, LAST;
      ASSIGN, ATRIB(1)=XX(31), ATRIB(2)=XX(32), ATRIB(3)=XX(33),
      ATRIB(4)=XX(34), ATRIB(9)=XX(35), ATRIB(13)=XX(36),
      ATRIB(19)=XX(37);
      ACT,,,CONT;

;
;
        KDOV STAGE
KDOV  GOON,1;
      ACT,, ATRIB(1).EQ. ATRIB(2), ME18;
      ACT;
      COLCT, BET, INTER AT KDOV,,1;
ME18  GOON,2;
      ACT,,,Q181;
      ACT;
      GOON,1;
      ACT/21, RNORM(24,,3,,3), ATRIB(11).GE. XX(2).OR. ATRIB(12).GE. XX(3), DEAD;
      ACT;
KD     GOON;
      ACT, UNFRM(13,,14,,3);
      ASSIGN, ATRIB(16)=TNOW;
      ACT,,,Q182;
Q181  QUEUE(28),,,,MA10; ACFT
Q182  QUEUE(18),,,,MA10; CREWS AVAIL
MA10  MATCH,5,Q181/AX8,Q182/AC8;
AX8   ASSIGN, XX(31)=ATRIB(1), XX(32)=ATRIB(2), XX(33)=ATRIB(3),
      XX(34)=ATRIB(4), XX(35)=ATRIB(9), XX(36)=ATRIB(13),

```

```

      XX(37)=ATTRIB(19);
ACB   ACCUM,2,2, LAST;
      ASSIGN,ATTRIB(1)=XX(31),ATTRIB(2)=XX(32),ATTRIB(3)=XX(33),
      ATTRIB(4)=XX(34),ATTRIB(9)=XX(35),ATTRIB(13)=XX(36),
      ATTRIB(19)=XX(37);
      ACT,,,CONT;
;*****
;                               ****MISSION CONTINUATION****
;*****
CONT  GOON;
      ACT/23;                               ENROUTE DEPARTURES
      ASSIGN,XX(19)=ATTRIB(19)-.5,XX(20)=ATTRIB(19)+.2,XX(38)=XX(10)-2;
      ASSIGN,ATTRIB(1)=ATTRIB(2),ATTRIB(6)=TNOW,1;          PRESENT NODE=ATTRIB(2)
      ACT/4,UNFRM(XX(19),XX(20)),XX(4),FLY;                NO MAJOR MX
      ACT/29,UNFRM(XX(20),XX(10),2),XX(5),FLY;            DELAY
      ACT/5,TRIA6(XX(38),XX(10),XX(10),3),XX(6),STAGE;     RAMP EXCEEDED
;*****
;                               ****CK MISSION QUEUES FOR WAIT TIME AND ALERT WINDOWS****
;*****
      CREATE,1,1,,3840;
      EVENT,2;
      EVENT,12;
      TERM;
;*****
;                               ****HOME****
;*****
HOME  GOON;
      EVENT,10,1;                               UPDATE 30/90 TIME
      COLCT,INT(8),MISSION LENGTH;                TRACK MSN LENGTHS
      COLCT,INT(6),LAST DUTY DAY;                  TRACK FINAL DUTY DAY
      ASSIGN,ATTRIB(10)=ATTRIB(10)+TNOW-ATTRIB(8);     TRACK TIME AWAY
      GOON;
      ASSIGN,XX(18)=XX(18)-1;
      ASSIGN,XX(26)=XX(25)+ATTRIB(7),ATTRIB(7)=0;      ACCUMULATE FLYING TIME
      ASSIGN,XX(25)=XX(26)-XX(27);                    FLY TIME THIS PHASE
      ASSIGN,XX(30)=XX(30)+TNOW-ATTRIB(6);             ACCUM. DUTY TIME
      ASSIGN,XX(23)=TNOW-XX(24),XX(39)=XX(30)-XX(40);  DUTY TIME THIS PHASE
      ASSIGN,XX(41)=XX(9)*XX(23)/730.56,XX(41)=XX(39)/XX(41);  AVG WORK MONTH
      ASSIGN,XX(42)=XX(9)*XX(23)/730.56,XX(42)=XX(25)/XX(42);  AVG FLY HOURS
      ASSIGN,XX(43)=XX(43)+TNOW-ATTRIB(8);             CUM. TIME AWAY
      ASSIGN,XX(44)=XX(43)-XX(45);                     TIME AWAY THIS PHASE
      ASSIGN,XX(46)=XX(9)*XX(23)/730.56,XX(46)=XX(44)*XX(46);  AVG TIME AWAY
      GOON,1;
      ACT,,ATTRIB(2).EQ.30,HM20;
      ACT;
      ASSIGN,XX(17)=XX(17)+1;                          ACFT INBOUND
      COLCT,XX(25),SYS FLY TIME,,2;                    FLY TIME THIS PHASE
      ACT,USERF(2),,START;                              CREW AVAIL.
      ACT,USERF(3);                                      ACFT MX
      FREE,ACFT,1;
      ASSIGN,XX(17)=XX(17)-1;                          RESET COUNTER, ACFT INBOUND

```

```

        ASSIGN,XX(18)=XX(18)+1;
        TERM;
HM30  ASSIGN,XX(58)=XX(58)+1;
        COLCT,XX(25),SYS FLY TIME,,2;
        ACT,USERF(2),,START;
        ACT,USERF(3);
        FREE,BACFT/1;
        ASSIGN,XX(58)=XX(58)-1;
        ASSIGN,XX(18)=XX(18)+1;
        TERM;
;*****
;                                     ****UNSUCCESSFUL HOMESTATION PREFLIGHT****
;*****
XCL  GOON;
        ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);          ADD DUTY TIME
        ASSIGN,XX(18)=XX(18)+1;
        GOON,2;          RAMP EXCEEDED
        ACT,,,START;          CREW BACK TO CREW REST
        ACT/9,UNFRM(3,12,2);
        EVENT,1,1;          IS BRAVO AVAIL?
        ACT/25,,ATRIB(17).NE.0,QUE6;          BRAVO AVAIL-REMATCH
        ACT;
        GOON,2;
        ACT,,,Q10;          RESCHEDULE MISSION
        ACT,,ATRIB(1).EQ.30,FR1;
        ACT,,ATRIB(1).EQ.10;
        FREE,ACFT/1;
        TERM;
FR1  FREE,BACFT/1;
        TERM;
XCLD GOON;
        ASSIGN,XX(30)=XX(30)+TNOW-ATRIB(6);
        GOON,2;          DUTY DAY EXCEEDED AT HOME
        ACT,,,START;
        ACT;
        EVENT,1,1;          IS BRAVO AVAIL?
        ACT,,ATRIB(17).NE.0,QUE6;          BRAVO AVAIL-REMATCH
        ACT;
        GOON,2;
        ACT,,,Q10;          RESCHEDULE MISSION
        ACT;
        GOON,1;
        ACT,,ATRIB(2).EQ.30,FR2;
        ACT;
        FREE,ACFT/1;
        TERM;
FR2  FREE,BACFT/1;
        TERM;
XCLA GOON,1;
        ACT/18;          COUNT MISSIONS CANCELLED DUE TO NO ACFT
        TERM;

```

```

:*****SCHEDULED MAINTENANCE*****
:
:*****
:
: A.C.1 AND REFURB NOT ACCOMPLISHED DURING SURGE
: HOMESTATION CHECK: 2 DAYS DOWN EACH 60 DAYS
:
: CREATE,XX(47),0;
: GOON;
: ACT,,,AW30;
: ACT;
: AWAIT(1),ACFT;
: ASSIGN,XX(18)=XX(18)-1;
: ACT/29,RNORM(48.,1.,3);
: ASSIGN,XX(18)=XX(18)+1;
: FREE,ACFT/1;
: TERM;
AW30 AWAIT(30),BACFT;
: ASSIGN,XX(18)=XX(18)-1;
: ACT/29,RNORM(48.,1.,3);
: ASSIGN,XX(18)=XX(18)+1;
: FREE,BACFT/1;
: TERM;
: REFURBISHMENT: 10 DAYS DOWN EACH 18 MOS
:
: CREATE,XX(48),0;
: GOON,1;
: ACT,,XX(49).EQ.1.TERM;
: ACT;
: GOON;
: ACT,,,AW32;
: ACT;
: AWAIT(1),ACFT;
: ASSIGN,XX(18)=XX(18)-1;
: ACT/30,RNORM(240.,5.,3);
: ASSIGN,XX(18)=XX(18)+1;
: FREE,ACFT/1;
TERM TERM;
AW32 AWAIT(30),BACFT;
: ASSIGN,XX(18)=XX(18)-1;
: ACT/30,RNORM(240.,5.,3);
: ASSIGN,XX(18)=XX(18)+1;
: FREE,BACFT/1;
: TERM;
: A.C.1. (REPLACING ISOCH): 10 DAYS DOWN EACH 18 MOS
: ARBITRARILY START AT 100
:
: CREATE,XX(50),100;
: GOON,1;
: ACT,,XX(49).EQ.1.TERM;
: ACT;
: GOON;
: ACT,,,AW33;
: ACT;
: AWAIT(1),ACFT;
: ASSIGN,XX(18)=XX(18)-1;

```

```

ACT/31,RNORM(720.,10.,3);
ASSIGN,XX(18)=XX(18)+1;
FREE,ACFT/1;
TERM;
AW33 AWAIT(30),BACFT;
ASSIGN,XX(18)=XX(18)-1;
ACT/31,RNORM(720.,10.,3);
ASSIGN,XX(18)=XX(18)+1;
FREE,BACFT/1;
TERM;
;*****
;          ***DEADHEAD HOME; EXCEEDED FLY TIME***
;*****
DEAD QUEUE(7);
ACT;
COLCT,INT(9),MISSION LENGTH;          TRACK MISSION LENGTH
ASSIGN, ATRIB(10)=ATRI(10)+TNOW-ATRI(9);          TIME AWAY
ASSIGN,XX(30)=XX(30)+UNFRM(8.,16.,2),XX(23)=TNOW-XX(24);
ASSIGN,XX(43)=XX(43)+TNOW-ATRI(8),XX(44)=XX(43)-XX(45);
ASSIGN,XX(46)=XX(9)*XX(23)/730.56,XX(46)=XX(44)/XX(46);          AWAY
ASSIGN,XX(39)=XX(30)-XX(40);
ASSIGN,XX(41)=XX(9)*XX(23)/730.56,XX(41)=XX(39)/XX(41);          WORK
500N;
ASSIGN,XX(26)=XX(26)+ATRI(7),ATRI(7)=0;          ACCUM FLY TIME
ASSIGN,XX(25)=XX(26)-XX(27);
ASSIGN,XX(42)=XX(9)*XX(23)/730.56,XX(42)=XX(25)/XX(42);          FLY
COLCT,XX(25),SYS FLY TIME,,2;
ACT,USERF(2)..START;          CREW AVAIL.
ACT;
TERM;
ENDNETWORK;
SEEDS,55120(1)/NO,4382635(2)/NO;
;
;*****DESCRIPTION OF COMPONENTS*****
;*****
;QUEUES
; 1) HOME STATION SCHEDULED MAINTENANCE
; 2) CREW PRIOR TO MISSION ASSIGNMENT
; 3) MISSION
; 4) AWAIT ACFT
; 5) CREW PRIOR TO MATCHING WITH MISSION (MAT1)
; 6) MSN PRIOR TO MATCHING WITH CREW (MAT2)
; 7) DEADHEAD TRANSITION
; 8) BRAVO CREW FILE
; 9) BRANCHING FOR WINDOW (FORTRAN)
; 10) B BRAVO*
; 11-19) CREW ENROUTE
; 20-29) ACFT ENROUTE
; 30) AWAIT INSP BACFT
; 31) AWAIT BACFT

```

:ACTIVITIES

- : 1) CREW REST
- : 2) STAGE
- : 3) PREFLIGHT HOME STATION - ON TIME
- : 4) PREFLIGHT/MX AT STAGE
- : 5) FLY
- : 6) RAMP EXCEEDED ENROUTE
- : 7) RAMP EXCEEDED AT HOME
- : 8) QUICK TURN GND TIME
- : 9) MX AFTER XCL
- : 10) NUMBER OF MISSIONS
- : 11-17) BASE COUNT
- : 18) CANCELL NO ACFT
- : 19) DUTY DAY CANCEL
- : 20) EXCEEDS 30/90 LIMITS AT HOME
- : 21) EXCEEDS 30/90 LIMITS IN SYSTEM
- : 22) # MSNS NOT CANCELLED PRIOR TO PREFLIGHT
- : 23) # ENROUTE MISSIONS
- : 24) DEPARTURES
- : 25) BRAVO FLIES
- : 26) DUTY DAY XCL AT HOME
- : 27) PREFLIGHT HOME STATION - LATE DEPARTURE
- : 28) PREFLIGHT ENROUTE - LATE DEPARTURE
- : 29) HSC
- : 30) REFURB
- : 31) A.C.I.
- : 32) APPROACHING 30 DAY LIMIT
- : 33) APPROACHING 90 DAY LIMIT
- : 34) CR FOR BRAVO

:USERFS

- : 1) FLY TIME
- : 2) HOME CREW REST
- : 3) MX
- : 4) CALC MISSION FREQ TO MEET TUP
- : 5) STAGE

:ATTRIBUTES

- : 1) PRESENT NODE
- : 2) NEXT NODE
- : 3) SORTIE FLY TIME
- : 4) STAGE=1
- : 5) BASIC=1
- : 6) SHOW TIME FOR DAY
- : 7) CUM. FLY TIME
- : 8) SHOW TIME FOR MSN
- : 9) ROUTE NUMBER
- : 10) CUM. TIME AWAY FROM HOME
- : 11) CUM. FLY TIME FOR 30 DAYS
- : 12) CUM. FLY TIME FOR 90 DAYS
- : 13) WHICH LES NUMBER
- : 14) CREW ID
- : 15) DAILY CUM FLY TIME

; 16) START TIME MISC
 ; 17) MISSION FOR BRAVO CREW
 ; 18) EVENT NUMBER
 ; 19) SCHED GROUND TIME
 ; 20) NLEGS IN MISSION
 ; SLAM
 ; 1) STAGING POLICY - 1 CREW FOR EVERY 27 ARRIVALS
 ; 2) 30 DAY FLY TIME LIMIT
 ; 3) 90 DAY FLY TIME LIMIT
 ; 4) ON-TIME PROBABILITY
 ; 5) DELAY PROBABILITY
 ; 6) RESCHEDULE PROBABILITY
 ; 7) PERCENT AVAILABLE
 ; 8) CREW RATIO
 ; 9) # CREWS CREATED
 ; 10) MAX RAMP TIME
 ; 11) ALERT WINDOW
 ; 12) # OF HOURS AFTER WHICH MSN IS CANCELLED IF NO ACFT OR CREW
 ; 13) COUNTER FOR CREW ID
 ; 14) NNO(2)
 ; 15) MISSION FREQUENCY
 ; 16) RESOURCE COUNT OF INBOUND ACFT
 ; 17) ACFT HOME PENDING MAINTENANCE
 ; 18) # PMC ACFT
 ; 19) MISC
 ; 20) MISC
 ; 21) MISC
 ; 22) NUMBER OF LEGS
 ; 23) TIME SINCE PHASE CHANGE
 ; 24) TIME OF PHASE CHANGE
 ; 25) FLY TIME SINCE PHASE CHANGE
 ; 26) SYSTEM FLY TIME
 ; 27) FLY TIME AT PHASE CHANGE
 ; 28) UTE RATE
 ; 29) # ACFT CREATED
 ; 30) ACCUM. DUTY HOURS
 ; 31-37) SAVE ATTRIBUTES AT STAGE BASES
 ; 38) MISC
 ; 39) DUTY TIME SINCE PHASE CHANGE
 ; 40) DUTY TIME AT PHASE CHANGE
 ; 41) AVG WORK MONTH
 ; 42) AVG MO FLY HOURS
 ; 43) TOTAL TIME FROM HOME
 ; 44) TIME AWAY SINCE PHASE CHANGE
 ; 45) TIME AWAY AT PHASE CHANGE
 ; 46) AVG MO TIME FROM HOME
 ; 47) FREQ OF HSC
 ; 48) FREQ OF REFURBISHMENT
 ; 49) 0=PEACE, 1=SURGE, 2=SUSTAINED
 ; 50) FREQ OF ACI
 ; 51) RENEGES FROM RESCHEDULING

: 52) STAGE CREW UTILIZED
 ; 53) INDEX FOR CREW REST (2=PEACE/SUSTAINED, 4=SURGE)
 : 54) 30 DAY FLY TIME
 ; 55) 90 DAY FLY TIME
 : 56) * EXCEEDING ALERT WINDOW
 ; 57) BACFT AVAIL + INBOUND
 ; 58) BACFT INBOUND
 ; 59) HOME STATION FOR MISSION

;
 INIT,0,3842; 3600 4.5 MOS + 480 HR WARM UP
 MONTR,CLEAR,600;
 MONTR,SUMRY,1681,1080; SUMMARY EACH PHASE
 SIMULATE;
 FIN;

APPENDIX G

FORTTRAN Main for Multiple Homebase

```
PROGRAM MAIN
  DIMENSION NSET(40000)
  COMMON/SCDM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
  COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSE
1,NBASE(10,0:10),STAGE(10,10),SET(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSE(10),TURSU,HRSMD,EXPFLY
  COMMON/FLY/ACFLTM(216,91),MAN,N
  COMMON QSET(40000)
  EQUIVALENCE(NSET(1),QSET(1))
  NNSET=40000
  NCRDR=5
  NPRNT=6
  NTAPE=7
  NPLOT=2
  CALL SLAM
  STOP
  END
  SUBROUTINE EVENT(JEVNT)
  COMMON/SCDM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
  COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSE
1,NBASE(10,0:10),STAGE(10,10),SET(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSE(10),TURSU,HRSMD,EXPFLY
  COMMON/FLY/ACFLTM(216,91),MAN,N
  DIMENSION NSET(40000)
  COMMON QSET(40000)
  EQUIVALENCE(NSET(1),QSET(1))
  GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14) JEVNT
1  CALL BRAVO
  RETURN
2  CALL CANCEL
  RETURN
3  CALL MIDUP
  RETURN
4  CALL MISSION
  RETURN
5  CALL NEXT
  RETURN
6  CALL STAGEDR
  RETURN
7  CALL SURGE
  RETURN
8  CALL SUSTAIN
  RETURN
9  CALL UPBRAV(1)
  RETURN
```

```

10 CALL UPFLTM
   RETURN
11 CALL WARMUP
   RETURN
12 CALL WINDOW
   RETURN

C
13 CALL SPLIT
   RETURN
14 CALL UPBRAV(2)
   RETURN
   END
   SUBROUTINE BRAVO
C *****IS BRAVO CREW AVAILABLE?
C                               REWRITTEN FOR MULTI-BASE
COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCPDR,NPENT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON QSET(40000)
DIMENSION NSET(40000)
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION A(34)
NQB=NNQ(8)
NQ10=NNQ(10)
IF (ATTRIB(1).EQ.10..AND.NQB.EQ.0) GO TO 12
IF (ATTRIB(1).EQ.30..AND.NQ10.EQ.0) GO TO 12
IF (ATTRIB(1).EQ.10..AND.NQB.NE.0) CALL RMV(1,9,A)
IF (ATTRIB(1).EQ.30..AND.NQ10.NE.0) CALL RMV(1,10,A)
A(9)=ATTRIB(9)
A(17)=ATTRIB(1)
XX(52)=ATTRIB(1)
CALL FILEM(5,A)
ATTRIB(17)=ATTRIB(1)
12 IF (ATTRIB(1).EQ.10.) CALL UPBRAV(1)
   IF (ATTRIB(1).EQ.30.) CALL UPBRAV(2)
   RETURN
   END
   SUBROUTINE CANCEL
C *****CANCEL IF IN SCHEDULED MSN QUEUE(1) FOR MORE THAN 12 HRS.
COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCPDR,NPENT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
DIMENSION NSET(40000)
COMMON QSET(40000)
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION B(34)
INTEGER RANK
RANK=1
NY=NNQ(3)
9 IF (RANK.GT.NY) GO TO 11
CALL COPY(RANK,3,B)
TT=TNOW-B(16)
IF (TT.LE.XX(12)) GO TO 11

```

```

C      IF (B(1).EQ.10.) XX(17)=XX(17)+1
      IF (B(1).EQ.30.) XX(58)=XX(58)+1
      CALL RMVDE(RANK,3,B)
      NY=NY-1
      XX(51)=XX(51)+1
      GO TO 9
11     RETURN
      END
      SUBROUTINE MIDUP
C      *****CHANGE DAY FOR UPFLTM
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCRDR,NPRNT,NNRUN,NNSSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/FLY/ACFLTM(216,91),MAN,N
      IF (N.EQ.91) THEN
        N=1
      ELSE
        N=N+1
      ENDIF
      DO 30 L=1,216
        IF (N.EQ.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1)) THEN
          ACFLTM(L,N)=ACFLTM(L,91)
        ELSEIF (N.EQ.91.AND.ACFLTM(L,N).LT.ACFLTM(L,1)) THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ELSEIF (N.LE.90.AND.N.GT.1.AND.ACFLTM(L,N).LT.ACFLTM(L,N+1))
        THEN
          ACFLTM(L,N)=ACFLTM(L,N-1)
        ENDIF
30     CONTINUE
      ATRIB(19)=3.
      CALL BCNBL(1.,2400E+00,ATRIB)
      ATRIB(19)=0.
      RETURN
      END
      SUBROUTINE MISSION
C      *****WHICH MISSION?
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCRDR,NPRNT,NNRUN,NNSSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
      1,NEAPE(10),N(10),STAGE(10,10),EGT(10,10),BAT(10,10),NACFT,ROUTE
      1,FREQSL(10),FREQSS(10),TURFSU,HFEMO,EXPFY
      X=DFAND(2)
      CUM=0
      NP=1
      DO 25 J=1,NUMTE
        IF (XX(49).EQ.0) CUM=CUM+FREQPC(J)
        IF (XX(49).EQ.1) CUM=CUM+FREQSG(J)
        IF (XX(49).EQ.2) CUM=CUM+FREQSU(J)
        IF (X.GE.CUM) NP=NP+1
25     CONTINUE
      ATRIB(19)=(BASE-NP,3)

```

```

C      XX(EP)=NBASE(NP,0)
      ATRIB(9)=NP
      RETURN
      END
      SUBROUTINE NEXT
C      *****NEXT LES
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
      1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
      1,FREQSU(10),FREQSG(10),TURSU,HRSMD,EXPFLY
      ATRIB(13)=ATRIB(13)+1
      ATRIB(2)=NBASE(ATRIB(9),ATRIB(13))
      ATRIB(3)=SAT(ATRIB(9),ATRIB(13))
      ATRIB(4)=STAGE(ATRIB(9),ATRIB(13))
      ATRIB(5)=1
      ATRIB(19)=SGT(ATRIB(9),ATRIB(13))
      ATRIB(20)=NLESS(ATRIB(9))
      RETURN
      END
      SUBROUTINE SPLIT
C      *****DIVIDES CREWS BETWEEN BASES
C      NEW FOR MULTI-BASES
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      I=ATRIB(14)
      IF (MOD(I,2).EQ.0) THEN
        ATRIB(1)=30.
        ATRIB(2)=30.
      ELSE
        ATRIB(1)=10.
        ATRIB(2)=10.
      ENDIF
      RETURN
      END
      SUBROUTINE STAGEDP
C      *****POSITION STAGE CREWS
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
      1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
      1,FREQSU(10),FREQSG(10),TURSU,HRSMD,EXPFLY
      DIMENSION NSET(40000)
      COMMON/DSET(40000)
      EQUIVALENCE(NSET(1),DSET(1))
      DIMENSION A(34),NNTOT(18)
      DO 1 I=1,19
        NNTOT(I)=0
1      CONTINUE
      DO 15 I=1,NUMRTE

```

```

      DO 20 J=1,NLESS(I)-1
        IF (STAGE(I,J).EQ.1) THEN
          NB=NBASE(I,J)
          IF (XX(49).EQ.0) NNTOT(NB)=NNTOT(NB)+FREQPC(I)*(HRSMO/
1EXPFLY)/XX(1)
          IF (XX(49).EQ.1) NNTOT(NB)=NNTOT(NB)+FREQS6(I)*(HRSMO/
1EXPFLY)/XX(1)
          IF (XX(49).EQ.2) NNTOT(NB)=NNTOT(NB)+FREQSU(I)*(HRSMO/
1EXPFLY)/XX(1)
        ENDIF
20    CONTINUE
15    CONTINUE
      DO 25 K=11,18
        IF (XX(49).EQ.0) WRITE(NPRNT,100)K,NNTOT(K)
        IF (XX(49).EQ.1) WRITE(NPRNT,101)K,NNTOT(K)
        IF (XX(49).EQ.2) WRITE(NPRNT,102)K,NNTOT(K)
25    CONTINUE
      DO 22 K=11,18
21    IF (NNTOT(K).LT.NNQ(K)) THEN
        CALL ULINK(1,K)
        CALL LINK(7)
        GO TO 21
      ELSEIF (NNTOT(K).GT.NNQ(K)) THEN
        IF (NNQ(2).EQ.0) GO TO 22
        CALL RMOVE(1,2,A)
        A(2)=K
C      START MISSION FOR STAGE CREW ALLOWING FOR DEADHEAD & REST
        A(8)=TNOW-UNFRM(6.,16.,2)-12
        CALL FILEM(K,A)
        NNTOT(K)=NNTOT(K)-1
        GO TO 21
      ENDIF
22    CONTINUE
100   FORMAT(' PEACE STAGE CREWS AT ',I2,' ',I2)
101   FORMAT(' SURGE STAGE CREWS AT ',I2,' ',I2)
102   FORMAT(' SUSTAINED STAGE CREWS AT ',I2,' ',I2)
      RETURN
      END
      SUBROUTINE SURGE
C      *****TRANSITION TO SURGE
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCPDR,NPRNT,NNRUN,NNSST,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLESS(10),FREQPC(10),TURNS,TURS6
1,NBASE(10,0,10),STAGE(10,10),SGT(10,10),BAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQS6(10),TURS,HRSMO,EXPFLY
      XX(49)=1
      XX(50)=4
      XX(15)=USERF(4)
      XX(10)=12
      XX(11)=12
      C/24=+.1680E+04

```

```

      XX(27)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(43)
      NCREW=(XX(8)*NACFT*2/4)*XX(7)
      DO 10 I=1,NCREW
        CALL ENTER(1,A)
10    CONTINUE
      XX(9)=XX(9)+NCREW
      CALL STAGECR
      RETURN
      END
      SUBROUTINE SUSTAIN
C      *****TRANSITION TO SUSTAINED
      COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCPDR,NPRT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BRIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
      1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
      1,FREQSU(10),FREQSG(10),TURSUS,HRSMO,EXPFLY
      XX(49)=2
      XX(53)=2
      XX(15)=USERF(4)
      XX(10)=6
      XX(11)=6
      XX(24)=.2760E+04
      XX(27)=XX(26)
      XX(40)=XX(30)
      XX(45)=XX(43)
      CALL STAGECR
      RETURN
      END
      SUBROUTINE UPBRAV(K)
C      *****CHANGE BRAVO CREW EVERY 48 HRS OR WHEN UTILIZED
C      REWRITTEN FOR MULTI-BASE*
      COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCPDR,NPRT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(40000)
      DIMENSION NSET(40000)
      EQUIVALENCE(NSET(1),QSET(1))
      DIMENSION A(34),B(34)
      ATTRIB(19)=0.
      NQB=NNQ(9)
      NQ1=NNQ(10)
      GO TO (1,2),K
1    IF (XX(52).EQ.10).OR.NQB.EQ.0) GO TO 12
      CALL FMOVE(1,8,A)
      CALL FILEM(2,A)
12   NEXT=MMFE(2)
13   IF (NEXT.EQ.0).OR.NNACT(75).GE.1) GO TO 11
      CALL COPY(-NEXT,2,A)
      IF (A(1).EQ.10.) GO TO 15
      NEXT=NSUCR(NEXT)

```

```

      GO TO 13
15  CALL RMVDE(-NEXT,2,A)
      IF (ATRI(17).EQ.0) CALL FILEM(9,A)
      IF (ATRI(17).NE.0) CALL FILEM(32,A)
      GO TO 11
2   IF (XX(52).EQ.30..OR.NQ10.EQ.0) GO TO 17
      CALL RMVDE(1,10,A)
      CALL FILEM(2,A)
17  NEXT=MMFE(2)
14  IF (NEXT.EQ.0..OR.NNACT(34).GE.1) GO TO 18
      CALL COPY(-NEXT,2,A)
      IF (A(1).EQ.30.) GO TO 16
      NEXT=NSUCR(NEXT)
      GO TO 14
15  CALL RMVDE(-NEXT,2,A)
      IF (ATRI(17).EQ.0) CALL FILEM(10,A)
      IF (ATRI(17).NE.0) CALL FILEM(32,A)
      GO TO 19
11  NRANK=NFIND(1,NCLNR,18,0,9,0,0)
      IF (NRANK.NE.0) CALL RMVDE(NRANK,NCLNR,B)
      ATRI(18)=9.
      CALL SCHDL(9,.4800E+02,ATRI)
      ATRI(18)=0.
      XX(52)=0
      RETURN
18  NRANK=NFIND(1,NCLNR,18,0,14,0,0)
      IF (NRANK.NE.0) CALL RMVDE(NRANK,NCLNR,B)
      ATRI(18)=14.
      CALL SCHDL(14,.4800E+02,ATRI)
      ATRI(18)=0.
      XX(52)=0
      RETURN
      END
      SUBROUTINE UPFLTM
C *****UPDATE P0 AND 30 DAY TIME
      COMMON/SCOM1/ATRI(100),DB(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
      1,NCRDP,NFRNT,NNRUN,NNSCT,NTAPE,ES(100),SSL(100),TNEXT,TNOW,XX(100)
      COMMON/BEIAN/NUMRTE,BASIC(10),NLEGS(10),FREQPD(10),TURPD,TURSG
      1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,SCUTE
      1,FREDSU(10),FREGBS(10),TURSU,HPSMO,EXPFLY
      COMMON/FLACFLTM/C18,P1),MAN,N
      IF (N.EQ.P1) THEN
        N90=1
      ELSE
        N90=N+1
      ENDIF
      IF (N.GE.31) THEN
        N30=N-30
      ELSE
        N30=P1+N-30
      ENDIF

```

```

ATTRIB(12)=ACFLTM(ATTRIB(14),N)+ATTRIB(15)-ACFLTM(ATTRIB(14),N90)
ATTRIB(13)=ACFLTM(ATTRIB(14),N)+ATTRIB(15)-ACFLTM(ATTRIB(14),N30)
ACFLTM(ATTRIB(14),N90)=ACFLTM(ATTRIB(14),N)+ATTRIB(15)
ATTRIB(15)=0
IX(54)=ATTRIB(11)
IX(55)=ATTRIB(12)
RETURN
END

```

```

SUBROUTINE WARMUP
COMMON /SCOM/ ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDP,NPRNT,NRPUN,NNSSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
XX(24)=.6000E+07
XX(27)=XX(26)
XX(40)=XX(20)
XX(45)=XX(43)
RETURN
END

```

```

SUBROUTINE WINDOW
C *****CK ALERT WINDOW
COMMON /SCOM/ ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCRDP,NPRNT,NRPUN,NNSSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON /QSET/ QSET(40000)
DIMENSION NSET(40000)
EQUIVALENCE(NSET(1),QSET(1))
DIMENSION A(74), B(34)
INTEGER RANK,I,IFILE
RANK=1
I=4
Z=NRQ(1)
P IF RANK,GT,3) GO TO 11
CALL COPY(RANK,I,A)
IF TNOW-A(16),LE,XX(11)) GO TO 11
CALL RMV(RANK,I,A)
IF (I.EQ,4) THEN
  XX(17)=XX(17)+1
  TF=A(9)
  NRANK=NFIND(1,B,P,0,TF,0.0)
  CALL RMV(NRANK,S,B)
  XX(51)=XX(51)+1
ELSEIF (I.EQ,31) THEN
  XX(58)=XX(58)+1
  TF=A(9)
  NRANK=NFIND(1,B,P,0,TF,0.0)
  CALL RMV(NRANK,S,B)
  XX(51)=XX(51)+1
ENDIF
Z=Z+1
A(20)=1
CALL FILEM(9,A)
XX(56)=XX(56)+1
GO TO P

```

```

11 IF (I.EQ.4) THEN
    I=71
ELSEIF (I.EQ.71) THEN
    I=11
ELSE
    I=I+1
ENDIF
IF (I.LE.19) THEN
    Z=NNB(I)
    GO TO 9
ENDIF
RETURN
END
SUBROUTINE INTLC
C *****INITIALIZE
COMMON/SCOM/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
1,NCFDP,NPNT,NNPUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
COMMON/BRIAN/NUMTE,BASIC(10),NLESS(10),FREQPC(10),TURPC,TURSG
1,NBASE(10,3:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
1,FREQSU(10),FREQSG(10),TURSU,HRSMO,EXPFLY
DIMENSION NSET(40000)
COMMON/QSET(40000)
EQUIVALENCE(NSET(1),QSET(1))
COMMON/FLY/ACFLTM(216,91),MAN,N
CHARACTER*6 BASE(10,0:10)
NUMTE=0
WRITE(NPNT,200)
200 FORMAT('ROUTE DATA')
OPEN (UNIT=17, FILE='ROUTE1.',STATUS='OLD')
REWIND(17)
READ(17,*)ROUTE
10 IF (ROUTE.LE.9999) THEN
    READ(17,*)BASIC(ROUTE),NLESS(ROUTE),FREQPC(ROUTE)
1,FREQSG(ROUTE),FREQSU(ROUTE)
    READ(17,201)BASE(ROUTE,3),J=0,NLESS(ROUTE)
201 FORMAT(11A6)
    READ(17,*)STAGE(ROUTE,3),J=1,NLESS(ROUTE)
    READ(17,*)SGT(ROUTE,3),J=1,NLESS(ROUTE)
    READ(17,*)SAT(ROUTE,3),J=1,NLESS(ROUTE)
    WRITE(NPNT,202)ROUTE,BASIC(ROUTE),NLESS(ROUTE)
202 FORMAT('ROUTE: ',F2.0,2X,'1' IF BASIC: ',F2.0,2X,'NUMBER OF
1, LESS: ',12)
    WRITE(NPNT,203)FREQPC(ROUTE),FREQSG(ROUTE),FREQSU(ROUTE)
203 FORMAT('PEACE USAGE: ',F2.0,2X,' SURGE USAGE: ',F2.0,2X
1,' SUSTAINED USAGE: ',F2.0)
    WRITE(NPNT,204)BASE(ROUTE,3),J=0,NLESS(ROUTE)
204 FORMAT('BASES: ',5X,11A6)
    WRITE(NPNT,204)STAGE(ROUTE,3),J=1,NLESS(ROUTE)
204 FORMAT('STAGE: ',9X,11F6.0)
    WRITE(NPNT,205)SGT(ROUTE,3),J=1,NLESS(ROUTE)
205 FORMAT('SCHED SHD TIME: ',11F6.1)

```

```

WRITE(NPRINT,206) (SAT(ROUTE,J),J=1,NLESS(ROUTE))
206 FORMAT(' SCHED AIR TIME: ',11F5.1)
NUMRTE=NUMRTE+1
READ(13,*)ROUTE
GO TO 10
ENDIF
READ(13,*)NACFT,TURPC,TURSG,TURSU
WRITE(NPRINT,207)NACFT,TURPC,TURSG,TURSU
207 FORMAT(' TOTAL AIRCRAFT: ',12,' PEACE TUR: ',F5.2,' SURGE TUR: ',
1,F5.2,' SUSTAINED TUR: ',F5.2)
DO 25 ROUTE=1,NUMRTE
DO 30 J=0,NLESS(ROUTE)
IF (BASE(ROUTE,J).EQ.'KCHS') NBASE(ROUTE,J)=10
IF (BASE(ROUTE,J).EQ.'DYVR') NBASE(ROUTE,J)=11
IF (BASE(ROUTE,J).EQ.'ESXX') NBASE(ROUTE,J)=12
IF (BASE(ROUTE,J).EQ.'ARXX') NBASE(ROUTE,J)=13
IF (BASE(ROUTE,J).EQ.'DYXX') NBASE(ROUTE,J)=14
IF (BASE(ROUTE,J).EQ.'EDXX') NBASE(ROUTE,J)=15
IF (BASE(ROUTE,J).EQ.'ENXX') NBASE(ROUTE,J)=16
IF (BASE(ROUTE,J).EQ.'KTIK') NBASE(ROUTE,J)=17
IF (BASE(ROUTE,J).EQ.'KDOV') NBASE(ROUTE,J)=18
IF (BASE(ROUTE,J).EQ.'KWR') NBASE(ROUTE,J)=30
30 CONTINUE
25 CONTINUE
C PEACETIME CREW REST POLICY
XX(50)=2
C CUMULATIVE DISTRIBUTION OF MISSIONS
XX(12)=NACFT*2
XX(18)=NACFT*2
XX(47)=547.5*24/NACFT
XX(48)=547.5*24/NACFT
XX(50)=1095*24/NACFT
N=91
DO 40 I=1,216
ACFLT(I,91)=UNIFORM(50,120,120)
SC=ACFLT(I,91)
IF (SC.GE.125.) THEN
SC=UNIFORM(10,125,130)
ACFLT(I,91)=SC-SC
ELSEIF (SC.LT.125.) THEN
ACFLT(I,91)=UNIFORM(10,SC,20)
ENDIF
SC=ACFLT(I,91)
DO 50 K=2,90
ACFLT(I,K)=ACFLT(I,K-1)+(SC-SC)/29
50 CONTINUE
ACFLT(I,1)=0
DO 20 K=2,60
ACFLT(I,K)=ACFLT(I,K-1)+ACFLT(I,91)/59
20 CONTINUE
40 CONTINUE

```

```

C   MISSION FREQUENCY
    XX(15)=USERF(4)
    ATRIB(18)=0.
C   CALL SCHDL(7.,2400E+02,ATRIB)
    CALL SCHDL(7.,1681E+04,ATRIB)
    ATRIB(18)=9.
    CALL SCHDL(9.,4800E+02,ATRIB)
    ATRIB(18)=6.
    CALL SCHDL(6.,0100E+02,ATRIB)
    ATRIB(18)=8.
    CALL SCHDL(8.,2761E+04,ATRIB)
    ATRIB(18)=11.
    CALL SCHDL(11.,6000E+03,ATRIB)
    ATRIB(18)=14.
    CALL SCHDL(14.,4800E+02,ATRIB)
    ATRIB(18)=0.
    RETURN
    END
    SUBROUTINE DTPUT
C   *****OUTPUT
    COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
    1,NCRDR,NPNT,NRPUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
    COMMON/BRIAN/NUMTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
    1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
    1,FREQSU(10),FREQSS(10),TURNS,HRSMD,EXPFLY
    COMMON/FLY/ACFLTM(215,91),MAN,N
    WRITE(NPNT,100)XX(1)
102  FORMAT(' STAGE CREW FOR EVERY 1.F2.0.' ARRIVALS')
    WRITE(NPNT,100)XX(2),XX(3)
103  FORMAT(' TO 1.90 DAY LIMITS: 1.F4.0)
    WRITE(NPNT,104)XX(9)
104  FORMAT(' # CREWS AVAILABLE: 1.F4.0)
    WRITE(NPNT,105)XX(14),XX(15),XX(16)
105  FORMAT(' RELIABILITY FACTORS: 1.F5.1,2X,F5.1,2X,F5.1)
    RETURN
    END
    FUNCTION LSEFF(1FN)
    COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,NCLNR
    1,NCRDR,NPNT,NRPUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,TNOW,XX(100)
    COMMON/BRIAN/NUMTE,BASIC(10),NLEGS(10),FREQPC(10),TURPC,TURSG
    1,NBASE(10,0:10),STAGE(10,10),SGT(10,10),SAT(10,10),NACFT,ROUTE
    1,FREQSU(10),FREQSS(10),TURNS,HRSMD,EXPFLY
    COMMON/FLY/ACFLTM(215,91),MAN,N
    DIMENSION VAL(10)
    GO TO (1,2,3,4,5) 1FN
C   COMPUTE SCHED FLY TIME
    :   RETURN
C   *****COMPUTE HOME STATION CREW FEET
C   IF (XX(57).EQ.4) GO TO 6
    IF (X(TNOW-ATRIB(18)).LE.76) USERF=12
    IF (X(TNOW-ATRIB(18)).LE.216) USERF=(TNOW-ATRIB(18))/3

```

```

      IF (ITNOW-ATRIB(8)).GT.215) USERF=72
      RETURN
C      *****HOME STATION ESTIMATED UNSCHED MAINTENANCE
C      USERF=RNORM(6.,2.,3)
      RETURN
4     EXPFLY=0
C      *****COMPUTE SCHEDULING FREQUENCY FOR TARGET UTE RATE
C      HRS PER MO./ EXP FLY TIME = #MSNS PER MO.
C      726 HRS IN A MO./ MSNS PER MO. = FREQUENCY
      IF (XX(49).EQ.0) HRSMO=NACFT#TURPC#30.44
      IF (XX(49).EQ.1.) HRSMO=NACFT#TURS6#30.44
      IF (XX(49).EQ.2.) HRSMO=NACFT#TURS#30.44
      DO 15 I=1,NUMRTE
        VAL(I)=0
        DO 20 J=1,NLEES(I)
          VAL(I)=VAL(I)+SAT(I,J)
20      CONTINUE
        IF (XX(49).EQ.0) EXPFLY=EXPFLY+(FREQPC(I)*VAL(I))
        IF (XX(49).EQ.1.) EXPFLY=EXPFLY+(FREQSG(I)*VAL(I))
        IF (XX(49).EQ.2.) EXPFLY=EXPFLY+(FREQSU(I)*VAL(I))
15     CONTINUE
      USERF=720.56/(HRSMO/EXPFLY)
      RETURN
C      *****IS BASE A STAGING LOCATION?
5     USERF=STAGE(ATRIB(9),ATRIB(13))-1)
      RETURN
      USERF=0
      RETURN
      END

```

Appendix H

Scenario Extracts

This appendix contains the scenarios used for this study. They were provided by USAF/SAGM.

TABLE H.1

NATO Single Homebase Scenario

<u>Route #</u>	<u>Dest</u>	<u>Dest</u>	<u>GT</u>	<u>RT</u>	<u>Stage</u>
1	KCHS (10)	KPYX (17)	2.7	0.83	No
		EGXX (12)	2.7	7.72	Yes
		KCHS (10)	2.7	3.37	Yes
4	KCHS (10)	KPYX (17)	2.7	0.87	No
		CYXX (14)	2.3	3.23	Yes
		EDXX (15)	2.7	5.52	No
		EGXX (12)	2.7	1.21	Yes
		KCHS (10)	2.7	3.37	Yes
5	KCHS (10)	KPYX (17)	2.7	0.87	No
		CYXX (14)	2.7	3.23	Yes
		ENXX (15)	2.7	5.07	No
		EGXX (12)	2.7	2.84	Yes
		KCHS (10)	2.7	3.37	Yes
6	KCHS (10)	KPYX (17)	2.7	2.55	No
		CYXX (14)	2.7	4.70	Yes
		EDXX (15)	2.7	5.31	No
		EGXX (12)	2.7	1.21	Yes
		KCHS (10)	2.7	7.71	Yes

Route Frequency			
<u>Route #</u>	<u>Base Percentage</u>	<u>Surge Percentage</u>	<u>Sustained Percentage</u>
1	22.0	0.0	16.0
4	78.0	39.0	53.0
5	0.0	3.0	0.0
6	0.0	52.0	31.0

TABLE H.2

SWA Single Homebase Scenario

<u>Route #</u>	<u>Dept</u>	<u>Dest</u>	<u>GT</u>	<u>ET</u>	<u>Stage</u>
1	KWRI (10)	KDOV (11)	2.3	0.83	NO
		LPLA (12)	2.3	5.00	YES
		HEXX (13)	2.3	6.67	YES
		DOXX (14)	2.3	3.50	NO
		OEXX (15)	2.3	2.67	YES
		LPLA (12)	2.3	9.14	YES
		KWRI (10)	2.3	5.69	YES
2	KWRI (10)	KTIK (16)	2.3	3.11	NO
		LPLA (12)	2.3	7.06	YES
		HEXX (13)	2.3	6.67	YES
		DOXX (14)	2.3	3.50	NO
		OEXX (15)	2.3	2.67	YES
		LPLA (12)	2.3	9.14	YES
		KWRI (10)	2.3	5.69	YES
3	KWRI (10)	KPXX (17)	2.3	1.24	NO
		LPLA (12)	2.3	5.43	YES
		HEXX (13)	2.3	6.67	YES
		DOXX (14)	2.3	3.50	NO
		OEXX (15)	2.3	2.67	YES
		LPLA (12)	2.3	9.14	YES
		KWRI (10)	2.3	5.69	YES

Route Frequency			
<u>Route #</u>	<u>Peak Percentage</u>	<u>Surge Percentage</u>	<u>Sustained Percentage</u>
1	100.0	13.4	10.5
2	0.0	35.5	35.5
3	0.0	42.1	0.0

TABLE H.3

NATO Multiple Homebase Scenario

<u>Route #</u>	<u>Dept</u>	<u>Dest</u>	<u>GT</u>	<u>FT</u>	<u>Stage</u>
1	KWRI (30)	KDOV (18)	2.3	0.83	NO
		CYYR (11)	2.3	2.65	YES
		EDXX (15)	2.3	5.52	NO
		EGXX (12)	2.3	1.21	YES
		KWRI (30)	2.3	7.72	YES
2	KWRI (30)	KTIK (17)	2.3	3.11	NO
		CYYR (11)	2.3	4.30	YES
		EDXX (15)	2.3	5.51	NO
		EGXX (12)	2.3	1.21	YES
		KWRI (30)	2.3	7.72	YES
3	KCHS (10)	KPXX (13)	2.3	0.83	No
		EGXX (12)	2.3	7.72	Yes
		KCHS (10)	2.3	8.87	Yes
4	KCHS (10)	KPXX (13)	2.3	0.83	No
		CYXX (14)	2.3	3.23	Yes
		EDXX (15)	2.3	5.52	No
		EGXX (12)	2.3	1.21	Yes
		KCHS (10)	2.3	8.87	Yes
5	KCHS (10)	KPXX (17)	2.3	0.83	No
		CYXX (14)	2.3	3.23	Yes
		ENXX (15)	2.3	5.07	No
		EGXX (12)	2.3	2.64	Yes
		KCHS (10)	2.3	8.87	Yes
6	KCHS (10)	KTIK (17)	2.3	2.55	No
		CYYR (11)	2.3	4.30	Yes
		EDXX (15)	2.3	5.51	No
		EGXX (12)	2.3	1.21	Yes
		KCHS (10)	2.3	7.81	Yes
Route Frequency					
<u>Route #</u>	<u>Peace Percentage</u>	<u>Surge Percentage</u>	<u>Sustained Percentage</u>		
1	50.0	17.3	27.0		
2	0.0	32.0	27.0		
3	11.0	0.0	9.0		
4	39.0	20.0	29.0		
5	0.0	4.0	0.0		
6	0.0	26.7	19.0		

Appendix I

ANOVA

ANOVA Input Program

```
/PROBLEM      TITLE IS 'THESIS'.
/INPUT        VARIABLES ARE 13.
              FORMAT IS FREE.
              FILE IS 'anova1.dat'.
/VARIABLE     NAMES ARE ID,STAGE,FLYLMT,TUR,PERCENT,CR,RELIAB,
              GND,LEGS,AURPUR,AVGWORK,AVGFLY,CANCEL,AUR.
              ADD=1.
              LABEL IS ID.
TRANSFORM     IF (TUR EQ -1) THEN AUR=AURPUR*15.1.
              IF (TUR EQ 1) THEN AUR=AURPUR*15.1.
              USE=ID LE 54.
/GROUP        CODES(2) ARE -1,1.
              NAMES(2) ARE THIRTY,SIXTY.
              CODES(3) ARE -1,1.
              NAMES(3) ARE ONETWOFIVE,ONEFIVEZERO.
              CODES(4) ARE -1,1.
              NAMES(4) ARE THREEFIVE,FOURFIVE.
              CODES(5) ARE -1,1.
              NAMES(5) ARE EIGHTY,NINETY.
              CODES(6) ARE -1,1.
              NAMES(6) ARE FOUR,FIVE.
              CODES(7) ARE -1,1.
              NAMES(7) ARE NINEFOUREIGHT,NINEFIVEFIVE.
              CODES(8) ARE -1,1.
              NAMES(8) ARE TWOONE,TWOTHREE.
              CODES(9) ARE -1,1.
              NAMES(9) ARE NATO,SWA.
/DESIGN       GROUPING ARE 2,3,4,5,6,7,8,9.
              DEPENDENT IS 11.
              INCLUDED ARE 1,2,3,4,5,6,7,8,10,11,14,15,16,17,18,
              21,24,25,26,27,29,34,35,36,37,38,45,46,47,48,56,
              57,58,67,68,79.
END
```

Table I.1

Anova Data

1	1	1	1	1	1	1	1	1	.5671	112.0	73.38	0
2	-1	-1	-1	1	1	-1	-1	-1	.6294	105.0	84.80	0
3	1	-1	-1	-1	-1	1	-1	1	.6197	133.6	88.76	0
4	-1	1	1	-1	-1	-1	1	-1	.5961	148.3	91.23	310
5	1	1	1	1	-1	-1	-1	-1	.5907	127.6	80.54	0
6	-1	-1	-1	1	-1	1	1	1	.6841	144.2	87.39	4
7	1	-1	-1	-1	1	-1	1	-1	.6277	114.6	72.29	0
8	-1	1	1	-1	1	1	-1	1	.6472	130.5	79.08	4
9	1	1	-1	-1	1	1	-1	-1	.6401	114.5	73.63	0
10	-1	-1	1	-1	1	-1	1	1	.5938	136.5	85.14	0
11	1	-1	1	1	-1	1	1	-1	.6094	130.9	83.13	0
12	-1	1	-1	1	-1	-1	-1	1	.6748	143.6	86.17	78
13	1	1	-1	-1	-1	-1	1	1	.6775	154.8	97.36	7
14	-1	-1	1	-1	-1	1	-1	-1	.6023	147.2	92.18	107
15	1	-1	1	1	1	-1	-1	1	.5925	99.43	65.47	5
16	-1	1	-1	1	1	1	1	-1	.6322	105.4	65.06	0
17	-1	-1	-1	1	1	1	-1	1	.7053	116.1	72.61	0
18	1	1	1	1	1	-1	1	-1	.5992	105.6	65.73	0
19	-1	1	1	-1	-1	1	1	1	.6758	164.5	103.1	98
20	1	-1	-1	-1	-1	-1	-1	-1	.6386	143.9	91.82	2
21	-1	-1	-1	1	-1	-1	1	-1	.6335	130.6	80.93	3
22	1	1	1	1	-1	1	-1	1	.6969	143.4	94.86	0
23	-1	1	1	-1	1	-1	-1	-1	.5992	117.0	73.38	0
24	1	-1	-1	-1	1	1	1	1	.6001	114.5	72.47	0
25	-1	-1	1	-1	1	1	1	-1	.6255	127.0	75.67	0
26	1	1	-1	-1	1	-1	-1	1	.6907	122.6	79.44	0
27	-1	1	-1	1	-1	1	-1	-1	.6252	129.9	79.87	0
28	1	-1	1	1	-1	-1	1	1	.5139	108.7	71.17	0
29	-1	-1	1	-1	-1	-1	-1	1	.6460	167.4	93.90	18
30	1	1	-1	-1	-1	1	1	-1	.6794	145.7	91.37	0
31	-1	1	-1	1	1	-1	1	1	.6653	113.7	71.97	1
32	1	-1	1	1	1	1	-1	-1	.6850	99.92	64.16	0
33	1	-1	1	-1	-1	-1	1	-1	.5995	145.7	91.89	0
34	-1	1	-1	-1	-1	1	-1	1	.6636	161.2	96.06	72
35	1	1	-1	1	1	-1	-1	-1	.6378	103.7	65.56	0
36	-1	-1	1	1	1	1	1	1	.6534	129.5	77.95	0
37	1	-1	1	-1	1	1	-1	1	.4707	84.13	57.94	0
38	-1	1	-1	-1	1	-1	1	-1	.6298	118.0	72.76	0
39	1	1	-1	1	-1	1	1	1	.6722	135.8	85.92	0
40	-1	-1	1	1	-1	-1	-1	-1	.5985	129.9	91.63	0
41	1	-1	-1	1	-1	-1	-1	1	.6181	122.0	79.53	0
42	-1	1	1	1	-1	1	1	-1	.5920	130.2	80.82	167
43	1	1	1	-1	1	-1	1	1	.6733	125.8	82.28	0
44	-1	-1	-1	-1	1	1	-1	-1	.6495	119.6	74.68	0
45	1	-1	-1	1	1	1	1	-1	.6794	104.4	65.74	0
46	-1	1	1	1	1	-1	-1	1	.6665	116.2	73.07	0
47	1	1	1	-1	-1	1	-1	-1	.6065	145.7	92.87	0
48	-1	-1	-1	-1	-1	-1	1	1	.6627	167.5	99.79	7

Table I.1 cont.

49	-1	1	-1	-1	-1	-1	-1	-1	.6340	148.4	91.32	93
50	1	-1	1	-1	-1	1	1	1	.4787	111.6	73.27	0
51	-1	-1	1	1	1	-1	1	-1	.5979	106.1	65.58	0
52	1	1	-1	1	1	1	-1	1	.7060	110.1	72.70	0
53	-1	1	-1	-1	1	1	1	1	.6695	130.0	77.03	0
54	1	-1	1	-1	1	-1	-1	-1	.5976	116.0	77.25	5
55	-1	-1	1	1	-1	1	-1	1	.6857	147.6	92.95	31
56	1	1	-1	1	-1	-1	1	-1	.6320	129.5	80.81	0
57	-1	1	1	1	-1	-1	1	1	.6360	145.9	86.51	48
58	1	-1	-1	1	-1	1	-1	-1	.6387	127.1	91.23	0
59	-1	-1	-1	-1	1	-1	-1	1	.6695	129.0	76.73	6
60	1	1	1	-1	1	1	1	-1	.6102	118.0	74.75	0
61	-1	1	1	1	1	1	-1	-1	.5984	104.4	65.76	0
62	1	-1	-1	1	1	-1	1	1	.5560	97.88	57.27	0
63	-1	-1	-1	-1	-1	1	1	-1	.6795	148.2	91.89	312
64	1	1	1	-1	-1	-1	-1	1	.7068	137.8	108.4	1

Appendix J

Regression Analysis

TABLE J.1

Center Point and Axial Data

65	0	0	0	0	0	0	-1	1	.6968	136.2	87.08	0
66	0	0	0	0	0	0	-1	1	.6859	136.5	86.20	0
67	0	0	0	0	0	0	-1	1	.6897	137.2	86.08	0
68	0	0	0	0	0	0	-1	1	.7051	137.6	88.06	0
69	0	0	0	0	0	0	-1	1	.6840	136.8	85.24	0
70	0	0	0	0	0	0	-1	1	.6981	138.0	87.53	0
71	0	0	0	0	0	0	-1	1	.7141	137.3	89.24	0
72	0	0	0	0	0	0	-1	1	.7087	137.7	88.41	0
73	0	0	0	0	0	0	-1	1	.6667	131.4	83.30	0
74	0	0	0	0	0	0	-1	1	.7160	137.5	89.87	0
75	0	0	0	0	0	0	-1	1	.6872	134.8	85.84	0
76	0	0	0	0	0	0	-1	1	.6793	133.9	86.89	0
77	0	0	0	0	0	0	-1	-1	.6506	129.0	81.30	0
78	0	0	0	0	0	0	-1	-1	.6239	123.3	78.11	0
79	0	0	0	0	0	0	-1	-1	.6308	123.6	78.92	0
80	0	0	0	0	0	0	-1	-1	.6241	123.1	78.01	0
81	0	0	0	0	0	0	-1	-1	.6236	123.4	77.89	0
82	0	0	0	0	0	0	-1	-1	.6260	123.8	78.30	0
83	0	0	0	0	0	0	-1	-1	.6208	123.4	77.63	0
84	0	0	0	0	0	0	-1	-1	.6267	124.5	79.35	0
85	0	0	0	0	0	0	-1	-1	.6210	123.0	77.70	0
86	0	0	0	0	0	0	-1	-1	.6252	122.8	78.17	0
87	0	0	0	0	0	0	-1	-1	.6245	122.9	78.03	0
88	0	0	0	0	0	0	-1	-1	.6272	123.6	78.54	1
89	-2.828	0	0	0	0	0	-1	1	.4928	113.6	61.41	513
90	2.828	0	0	0	0	0	-1	1	.5175	100.4	64.38	1
91	0	-2.828	0	0	0	0	-1	1	.7290	67.07	41.31	5
92	0	2.828	0	0	0	0	-1	1	.6927	176.7	88.74	0
93	0	0	0	-2.828	0	0	-1	1	.6686	154.7	100.2	0
94	0	0	0	2.828	0	0	-1	1	.6873	111.7	72.62	0
95	0	0	0	0	-2.828	0	-1	1	.6910	186.3	126.1	9
96	0	0	0	0	2.828	0	-1	1	.7045	104.5	66.02	0
97	0	0	0	0	0	-2.828	-1	1	.6994	136.5	87.29	0
98	0	0	0	0	0	2.828	-1	1	.7708	176.0	91.57	0
99	-2.828	0	0	0	0	0	-1	-1	.5175	107.0	64.96	904
100	2.828	0	0	0	0	0	-1	-1	.6292	123.5	78.64	0
101	0	-2.828	0	0	0	0	-1	-1	.7303	65.04	41.36	3
102	0	2.828	0	0	0	0	-1	-1	.6265	124.4	78.33	0
103	0	0	0	-2.828	0	0	-1	-1	.6267	148.2	94.02	0
104	0	0	0	2.828	0	0	-1	-1	.6186	105.4	66.70	0
105	0	0	0	0	-2.828	0	-1	-1	.6182	179.1	113.0	142
106	0	0	0	0	2.828	0	-1	-1	.6164	92.68	58.57	0
107	0	0	0	0	0	-2.828	-1	-1	.6071	122.0	75.93	8
108	0	0	0	0	0	2.828	-1	-1	.6262	123.4	78.34	0

BMDP Regression Input for AUR

```
PROBLEM      TITLE IS 'AUR REGRESSION'.
INPUT        VARIABLES ARE 17.
             FORMAT IS FREE.
             FILE IS 'anova1.dat'.
VARIABLE     NAMES ARE ID,STAGE,FLYLMT,TUR,PERCENT,CR,RELIAB,
             GND,LEGS,AURPUR,AVGWORK,AVGFLY,CANCEL,AUR,SF,PR,SL,
             FL,SSQ,FSQ,PSQ,CSQ,RSQ,CG,SC,ABEG,DEFG,TSQ.
             ADD=15.
             LABEL IS ID.
TRANSFORM    IF (TUR EQ -1) THEN AUR=AURPUR*15.1.
             IF (TUR EQ 1) THEN AUR=AURPUR*16.1.
             IF (TUR EQ 0) THEN AUR=AURPUR*15.5.
             SF=STAGE*FLYLMT.
             PR=PERCENT*RELIAB.
             SL=STAGE*LEGS.
             FL=FLYLMT*LEGS.
             SSQ=STAGE*STAGE.
             FSQ=FLYLMT*FLYLMT.
             PSQ=PERCENT*PERCENT.
             CSQ=CR*CR.
             RSQ=RELIAB*RELIAB.
             CG=CR*GND.
             SC=STAGE*CR.
             ABEG=STAGE*FLYLMT*CR*GND.
             DEFG=PERCENT*CR*RELIAB*GND.
             TSQ=TUR*TUR.
             USE=LESS EQ -1.
             DELETE=99 TO 100.
REGRESS      DEPENDENT IS AUR.
             INDEPENDENT ARE STAGE,CR,FLYLMT,PERCENT,SF,PR,RELIAB,
             FSQ,PSQ,SSQ,CSQ,RSQ,TUR,TSQ.
             METHOD=NONE.
             TOL=.01.
PRINT       MATRICES ARE COVP, CORR, REG, RESI.
PLOT        YVAR ARE RESIDUAL,PREDICTD.
             XVAR ARE SPREDICTD,AVGWORK.
             NORMAL.
             SIZE IS 40,25.
END
```

TABLE J.2

EMDP Regression Results for AUF (SWA)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	2.41
SQUARED MULTIPLE CORRELATION	.76544
MULTIPLE CORRELATION	.97489
ADJUSTED SQUARED MULT. CORR.	.73878
RESIDUAL MEAN SQUARE	.191196
STANDARD ERROR OF EST.	.437250
F-STATISTIC	28.72
NUMERATOR DEGREES OF FREEDOM	5
DENOMINATOR DEGREES OF FREEDOM	44
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T- STAT.	2TAIL SIG.	CONTRI- TOL- ERANCE TO R-SQ
INTERCEPT	10.8975	.109715	12.738	99.69	.000	
2 STAGE	-.386944	.0772974	-.365	-5.01	.000	1.000000 .13359
3 FLYVMT	.447644	.0772974	.423	5.79	.000	1.000000 .17879
15 PR	.543290	.0772974	.513	7.03	.000	1.000000 .26334
21 PSC	-.0440955	.0410955	-.079	-1.08	.288	.998745 .00615
23 TSG	-.751031	.128910	-.426	-5.83	.000	.998745 .18095

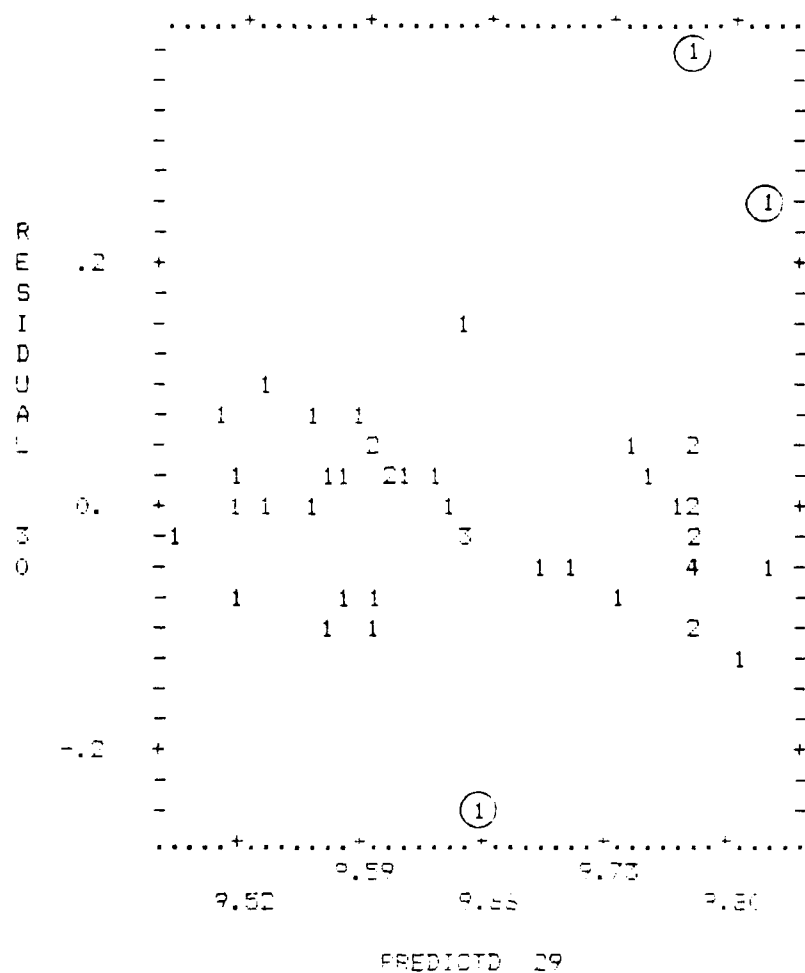
*significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

CASE No.	OBSERVED AUF	PREDICTED VALUE	STANDARD ERROR OF PREDICTION	STAND- ADJUSTED RESIDUAL	DELETED (PRESS)	ADJUSTED (PRESS)	MALLOWS' NOBIS DISTANCE	COOK DISTANCE
1	9.7467	10.7067	.1546	.6740	.69	.9788	10.7015	.00
2	9.7575	9.7045	.1546	.6770	1.55	.9774	9.6741	.06
3	10.7099	10.5849	.1546	-.0550	-.62	-.1915	10.6214	.01
4	10.4199	10.7877	.1546	.0263	.06	.9760	10.7899	.00
5	10.6700	10.5849	.1546	.5852	1.47	.9689	10.5013	.05
6	10.6895	10.7877	.1546	-.2042	-.50	-.1737	10.4228	.01
7	10.6707	10.7063	.1546	-.4741	-1.16	-.5441	10.7743	.03
8	9.5792	9.7245	.1546	.3148	1.29	.9712	8.6081	.09
9	10.6500	10.5849	.1546	.0651	.15	.9744	10.5756	.00
10	10.9804	10.7877	.1546	.4867	1.19	.9563	10.7241	.03
11	10.6201	10.7063	.1546	.5138	1.25	.9872	10.5729	.04
12	9.5145	9.7245	.1546	.7900	1.97	.9029	8.6115	.09

26	10.4296	10.7063	.1546	-.2768	-.68	-.3163	10.7459	5.14	.01
28	8.7704	8.7245	.1546	-.7541	-.87	-.4047	8.7751	5.14	.02
29	10.4006	10.5849	.1546	-.1843	-.45	-.2107	10.6113	5.14	.00
31	10.5594	10.7937	.1546	.1658	.41	.1955	10.7700	5.14	.00
34	10.3204	10.3937	.1546	-.3733	-.91	-.4266	10.4470	5.14	.02
36	10.5197	10.5849	.1546	-.0652	-.16	-.0745	10.5942	5.14	.00
37	7.5783	8.7245	.1546	-1.1462	-2.80	-1.3100	8.8882	5.14	.19
39	10.1502	10.7063	.1546	-.5561	-1.36	-.6356	10.7858	5.14	.04
41	9.3333	8.7245	.1546	.6088	1.49	.6958	8.6375	5.14	.05
43	10.8401	10.7063	.1546	.1338	.33	.1529	10.6872	5.14	.00
46	10.7306	10.3937	.1546	.3370	.82	.3851	10.3455	5.14	.02
48	10.4598	10.5849	.1546	-.1252	-.31	-.1430	10.6028	5.14	.00
50	7.7071	8.7245	.1546	-1.0174	-.49	-1.1628	8.8698	5.14	.15
52	10.6606	10.7063	.1546	-.0457	-.11	-.0523	10.7129	5.14	.00
57	10.1095	10.3937	.1546	-.2842	-.69	-.3248	10.4343	5.14	.01
55	11.0398	10.5849	.1546	.4548	1.11	.5198	10.5200	5.14	.02
57	10.2396	10.3937	.1546	-.1541	-.38	-.1761	10.4157	5.14	.00
59	10.1095	10.5849	.1546	-.4755	-1.16	-.5434	10.6529	5.14	.07
62	8.3956	8.7245	.1546	-.3289	-.80	-.3759	8.7715	5.14	.02
64	11.3795	10.7063	.1546	.6771	1.65	.7693	10.6102	5.14	.06
65	10.8701	10.8975	.1093	-.0274	-.06	-.0292	10.8993	2.08	.00
66	10.7900	10.8975	.1093	-.1974	-.47	-.2106	10.9104	2.08	.00
67	10.7593	10.8975	.1093	-.1782	-.33	-.1474	10.9067	2.08	.00
68	10.8994	10.8975	.1093	.1001	.24	.1089	10.8907	2.08	.00
69	10.8704	10.8975	.1093	-.0271	-.04	-.0242	10.9126	2.08	.00
70	10.8994	10.8975	.1093	-.1071	-.02	-.1065	10.8980	2.08	.00
71	11.1401	10.8975	.1093	.2928	.57	.2956	10.8317	2.08	.00
72	11.1495	10.8975	.1093	.1501	.36	.1501	10.8977	2.08	.00
77	11.4005	10.8975	.1093	-.4971	-1.17	-.5701	10.8704	2.08	.02
74	11.1694	10.8975	.1093	.0701	.14	.0907	10.8797	2.08	.00
75	11.7217	10.8975	.1093	-.1772	-.42	-.1990	11.5193	2.08	.00
76	10.8091	10.8975	.1093	.0816	.17	.1104	10.8947	2.08	.01
83	10.4700	10.5448	.0792	-.0747	-.17	-.0787	10.4555	17.62	.02
94	10.5595	10.5448	.0792	.0147	.17	.0287	10.4700	17.62	.01
95	10.7794	10.8975	.1093	-.1179	-.23	-.1257	10.8157	2.08	.00
96	10.8992	10.8975	.1093	.1907	.42	.1939	10.8917	2.08	.00
97	10.9106	10.8975	.1093	.0172	.17	.0140	10.8966	2.08	.00
98	11.4005	10.8975	.1093	.5070	1.19	.5765	10.8609	2.08	.02

#potential outliers



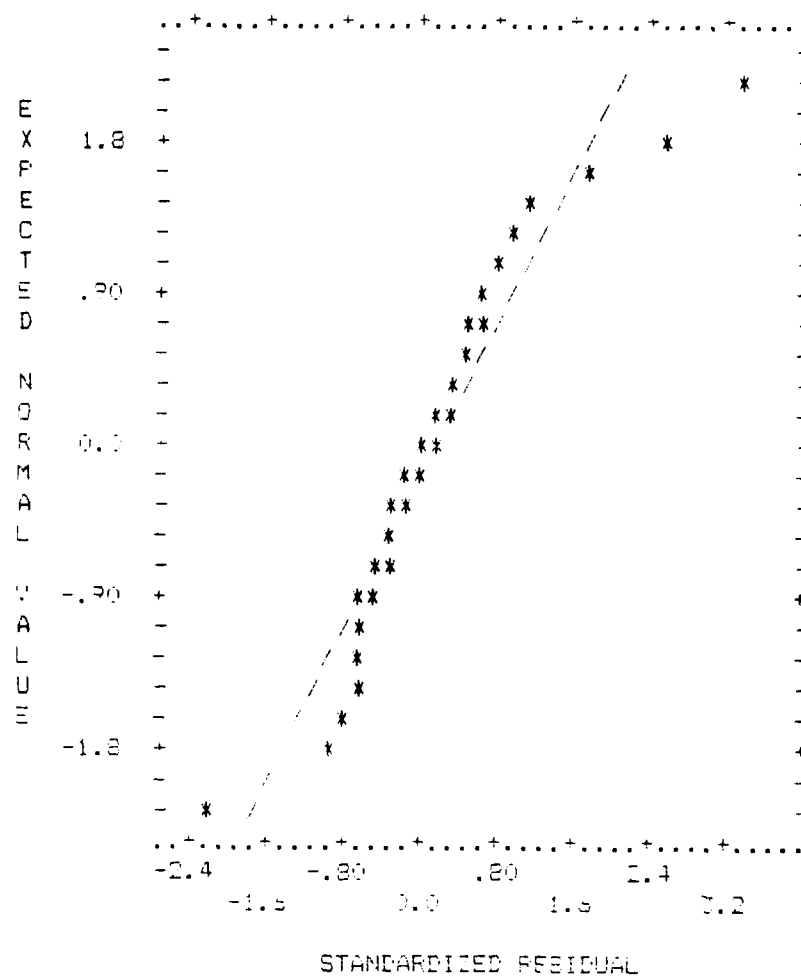


Fig. J.2. Normal Probability Plot--AUR

TABLE J.3

EMDP Regression Results for AUR (SWA) - Revised

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	4.87
SQUARED MULTIPLE CORRELATION	.65525
MULTIPLE CORRELATION	.80948
ADJUSTED SQUARED MULT. CORR.	.58427
RESIDUAL MEAN SQUARE	.064838
STANDARD ERROR OF EST.	.254633
F-STATISTIC	9.23
NUMERATOR DEGREES OF FREEDOM	7
DENOMINATOR DEGREES OF FREEDOM	34
SIGNIFICANCE (TAIL PROB.)	.0000

VARIBLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T- STAT.	TAIL P16.	CONTRI- TOL- BUTION ERANCE TO R-SQ
	INTERCEPT	10.8606	.0680534	27.501	159.59	.000	
2	STAGE	-.030477	.0766545	-.432	-3.01	.005	.490941 .09167
3	FLY-INT	.009126	.0759909	.588	4.07	.000	.485164 .16779
15	PR	.404763	.0759909	.770	5.33	.000	.485164 .29767
27	FEQ	.0068801	.0240678	.156	1.57	.133	.993272 .02381
21	FEQ	-.0034855	.0240678	-.167	-1.64	.110	.987072 .02729
4	TUR	.024798	.0572602	.435	4.22	.000	.956175 .13064
23	FEQ	-.599186	.0974381	-.760	-6.15	.000	.667951 .79343

*significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

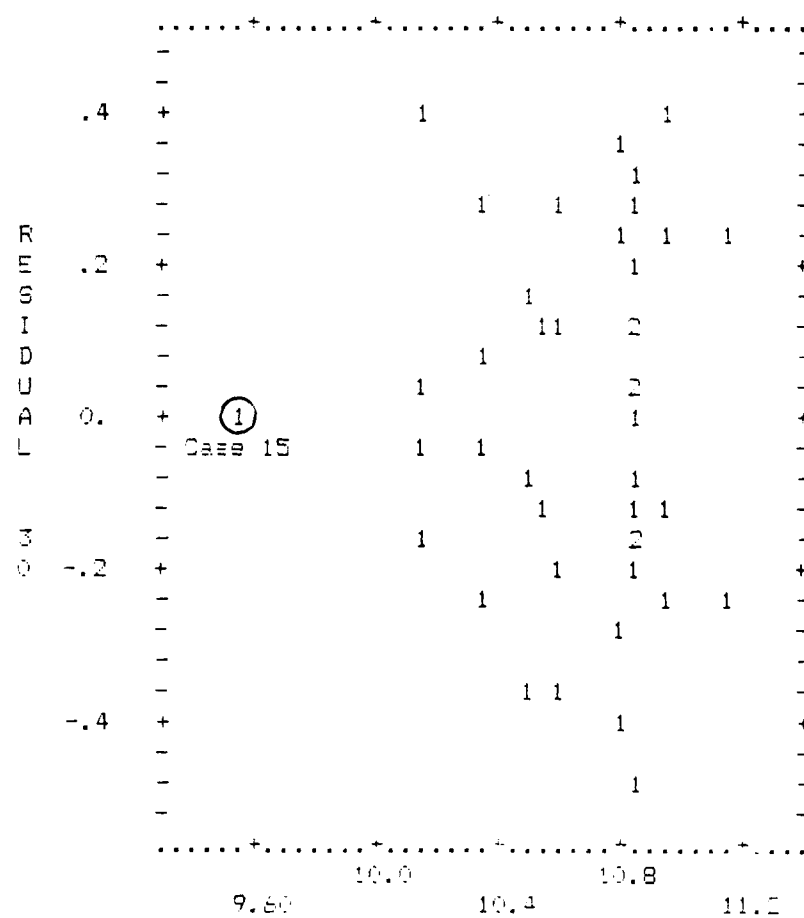


Fig. 3.7. Residual Plot Revised

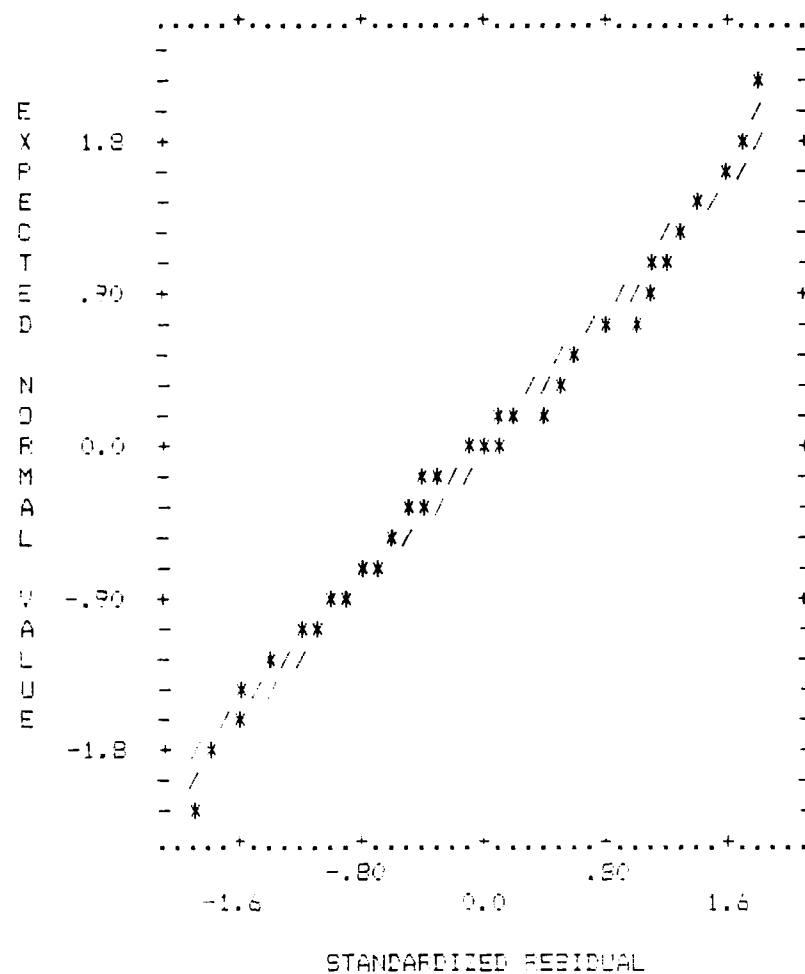


Fig. 3.4. Normal Probability Plot Revised

TABLE J.4

BMDP Regression Results for ALR (NATO)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	6.97
SQUARED MULTIPLE CORRELATION	.54700
MULTIPLE CORRELATION	.73959
ADJUSTED SQUARED MULT. CORR.	.45860
RESIDUAL MEAN SQUARE	.010375
STANDARD ERROR OF EST.	.101857
F-STATISTIC	6.19
NUMERATOR DEGREES OF FREEDOM	8
DENOMINATOR DEGREES OF FREEDOM	41
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T- STAT.	2TAIL SIG.	CONTRI- BUTION TOL- ERANCE TO R-SQ
INTERCEPT	9.77262	.0272224	70.596	358.99	.000	
3 FLYLMT	-.0229150	.0180059	-.133	-1.27	.212	1.000000 .01774
5 PERCENT	-.0789045	.0147025	-.285	-2.71	.010	1.000000 .08139
18 PR	-.0447992	.0180059	-.262	-2.49	.017	1.000000 .06339
7 RELIAB	.0467374	.0147025	.324	2.19	.037	1.000000 .11165
27 PSD	-.0191157	.00962749	-.210	-1.99	.054	.983179 .04756
22 DSD	-.0178479	.00962749	-.197	-1.85	.071	.993179 .03797
4 TUR	.0376987	.0180059	.220	2.09	.043	1.000000 .14843
29 TSD	-.105305	.0200530	-.769	-3.80	.001	.997175 .17566

*significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

TABLE J.5

BMDP Regression Results for AVGWGR (SWA)

STATISTICS FOR 'BEST' SUBSET

```

-----
MALLONS' CP          5.09
SQUARED MULTIPLE CORRELATION .92866
MULTIPLE CORRELATION .96367
ADJUSTED SQUARED MULT. CORR. .91678
RESIDUAL MEAN SQUARE 35.401574
STANDARD ERROR OF EST. 5.949922
F-STATISTIC          78.11
NUMERATOR DEGREES OF FREEDOM 7
DENOMINATOR DEGREES OF FREEDOM 42
SIGNIFICANCE (TAIL PROB.) .0000
-----

```

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T- STAT.	2TAIL SIG.	CONTRI- TOL- BUTION ERANCE TO R-SQ
INTERCEPT	135.912	1.48748	6.585	91.30	.000	
1 STAGE	-9.64875	1.05181	-.928	-8.17	.000	1.000000 .14293
5 CR	-14.7043	.858841	-.706	-17.12	.000	1.000000 .49788
7 FLYLMT	5.84875	1.05181	.229	5.55	.000	1.000000 .05152
5 PERCENT	-5.95310	.858841	-.374	-8.10	.000	1.000000 .11148
16 PR	7.10500	1.05181	.378	6.75	.000	1.000000 .07750
22 CSD	1.83649	.857974	.176	2.02	.002	.998745 .01940
28 TSD	-7.71649	1.75411	-.172	-4.17	.000	.998745 .02955

*significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

TABLE J.6

BMDP Regression Results for AVSWORK (NATO)

STATISTICS FOR 'BEST' SUBSET

```

-----
MALLOW'S CP              7.16
SQUARED MULTIPLE CORRELATION .98776
MULTIPLE CORRELATION    .99386
ADJUSTED SQUARED MULT. CORR. .98539
RESIDUAL MEAN SQUARE    3.805333
STANDARD ERROR OF EST.  1.950726
F-STATISTIC             413.70
NUMERATOR DEGREES OF FREEDOM  8
DENOMINATOR DEGREES OF FREEDOM 41
SIGNIFICANCE (TAIL PROB.) .0000
-----

```

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL- ERANCE	CONTRI- BUTION TO R-SQ
	INTERCEPT	123.700	.521354	7.668	237.27	.000		
2	STAGE	-1.11560	.344843	-.056	-3.23	.002	1.000000	.00312
8	CR	-14.0597	.281577	-.863	-49.97	.000	1.000000	.74516
5	PERCENT	-7.58656	.281577	-.465	-26.94	.000	1.000000	.21666
16	PR	-.515000	.344843	-.026	-1.49	.143	1.000000	.00067
21	PSQ	.387617	.184382	.037	2.10	.042	.993139	.00132
22	CSQ	1.52421	.194382	.144	8.27	.000	.993139	.02040
4	TUF	.791249	.344843	.020	1.13	.253	1.000000	.00038
28	TSQ	-1.23706	.575563	-.079	-2.23	.031	.997136	.00148

*significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

TABLE J.7

BMDP Regression Results for AVGFLY (SWA)

STATISTICS FOR 'BEST' SUBSET

```

-----
MALLONS' CP          5.53
SQUARED MULTIPLE CORRELATION .90763
MULTIPLE CORRELATION .95270
ADJUSTED SQUARED MULT. CORR. .39224
RESIDUAL MEAN SQUARE 16.870127
STANDARD ERROR OF EST. 4.107326
F-STATISTIC          58.96
NUMERATOR DEGREES OF FREEDOM 7
DENOMINATOR DEGREES OF FREEDOM 42
SIGNIFICANCE (TAIL PROB.) .0000
-----

```

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T- STAT.	2TAIL SIG.	TOL- ERANCE	CONTRI- BUTION TO R-SQ
INTERCEPT	87.2325	1.02683	6.972	94.95	.000		
2 STAGE	-3.24594	.726080	-.210	-4.47	.000	1.000000	.04395
3 CR	-9.27726	.592871	-.724	-15.64	.000	1.000000	.53805
7 FLYLMT	3.45094	.726080	.223	4.75	.000	1.000000	.04968
8 PERCENT	-4.24080	.592871	-.325	-7.15	.000	1.000000	.11252
16 PR	4.59031	.726080	.296	6.31	.000	1.000000	.08752
22 CSQ	1.10377	.385178	.134	2.87	.006	.998745	.01806
28 TSD	-6.32908	1.21089	-.245	-5.23	.000	.998745	.06008

*significant at 5%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

TABLE J.8

BMDP Regression Results for AVGFLY (NATO)

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	8.90
SQUARED MULTIPLE CORRELATION	.99012
MULTIPLE CORRELATION	.99505
ADJUSTED SQUARED MULT. CORR.	.98790
RESIDUAL MEAN SQUARE	1.253142
STANDARD ERROR OF EST.	1.119438
F-STATISTIC	445.49
NUMERATOR DEGREES OF FREEDOM	9
DENOMINATOR DEGREES OF FREEDOM	40
SIGNIFICANCE (TAIL PROBAB.)	.0000

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2-TAIL SIG.	CONTRIBUTION TOL- ERANCE TO R-SQ
	INTERCEPT	78.4125	.723154	7.705	242.65	.000	
5	CR	-9.84571	.161585	-.860	-54.74	.000	1.000000 .74007
6	PERCENT	-4.85929	.161595	-.473	-29.37	.000	1.000000 .32333
16	PR	-.334667	.197991	-.027	-1.39	.099	1.000000 .00071
7	REL148	.791451	.161595	.039	2.42	.020	1.000000 .00145
20	PSQ	-.165998	.106905	-.025	-1.55	.129	.967075 .00050
21	PSQ	.218507	.106905	.033	2.04	.046	.967075 .00103
22	PSQ	.91934	.106905	.179	8.61	.000	.967075 .01826
4	TUR	.317436	.197991	.025	1.59	.121	1.000000 .00062
29	TSD	-1.33029	.330646	-.062	-4.02	.000	.994999 .00400

*significant at 95%

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

Appendix K

Sensitivity Results

TABLE K.1

Crew Ratio Sensitivity

Crew Ratio Effect on AUR

CR	Rep1	Rep2	Rep3	Avg.	
4.0	3.621	3.629	3.676	3.642	Peace
4.2	3.704	3.643	3.608	3.652	
4.4	3.689	3.691	3.615	3.665	
4.6	3.685	3.690	3.695	3.690	
4.8	3.716	3.667	3.757	3.727	
5.0	3.677	3.721	3.606	3.637	
4.0	9.628	9.551	9.610	9.596	Surge
4.2	9.500	9.674	9.642	9.595	
4.4	9.712	9.633	9.604	9.650	
4.6	9.492	9.629	9.650	9.590	
4.8	9.945	9.549	9.942	9.812	
5.0	9.555	9.650	9.875	9.693	
4.0	8.261	7.361	8.212	7.511	Sustained
4.2	8.260	8.761	8.201	8.407	
4.4	8.582	10.02	8.643	8.418	
4.6	8.085	8.498	8.597	8.393	
4.8	10.28	10.03	10.22	10.177	
5.0	8.952	8.728	10.02	8.900	

Crew Ratio Effect on Avg Work Month

CR	Rep1	Rep2	Rep3	Avg.	
4.0	68.99	68.42	70.72	69.54	Peace
4.2	67.08	68.01	68.64	68.24	
4.4	64.16	64.72	67.35	65.44	
4.6	68.90	61.10	68.72	66.71	
4.8	69.89	68.22	60.91	66.56	
5.0	64.71	66.84	64.80	65.37	
4.0	146.9	146.7	145.9	146.4	Surge
4.2	138.2	139.0	140.1	139.1	
4.4	135.5	137.7	137.7	134.0	
4.6	137.4	127.3	129.0	127.9	
4.8	126.8	122.9	127.5	125.7	
5.0	117.7	116.9	121.1	118.4	
4.0	119.2	105.7	99.76	108.1	Sustained
4.2	127.8	133.2	125.4	128.6	

4.4	126.7	131.0	114.2	124.0	Sustained
4.6	114.2	120.2	120.8	118.4	
4.8	123.9	121.1	123.5	122.8	
5.0	114.1	112.0	116.1	114.1	

Effect of Crew Ratio on Avg Fly Hours

CR	Rep1	Rep2	Rep3	Avg.	
4.0	45.97	46.11	46.91	46.33	Peace
4.2	44.57	44.03	43.39	44.00	
4.4	42.78	42.71	41.92	42.47	
4.6	39.46	40.62	39.60	39.89	
4.8	39.42	38.98	40.41	39.60	
5.0	36.57	37.80	36.52	36.96	
4.0	81.63	80.78	81.41	81.27	Surge
4.2	86.09	87.11	87.41	86.87	
4.4	84.79	87.70	83.48	83.99	
4.6	78.35	80.14	80.11	79.7	
4.8	79.71	76.59	79.71	78.67	
5.0	72.69	73.53	75.17	73.80	
4.0	78.78	70.05	65.86	71.56	Sustained
4.2	83.80	88.22	83.14	85.05	
4.4	83.39	87.17	78.18	81.91	
4.6	78.38	78.94	79.73	78.01	
4.8	82.44	80.33	81.83	81.53	
5.0	78.73	74.12	76.23	76.36	

Effect of Crew Ratio on Time Away

CR	Rep1	Rep2	Rep3	Avg.	
4.0	151.9	153.8	164.7	153.5	Peace
4.2	154.9	155.6	153.2	154.6	
4.4	149.3	149.5	148.2	149.1	
4.6	132.8	142.1	139.7	138.1	
4.8	137.1	136.6	139.0	137.6	
5.0	130.3	132.4	129.6	131.0	
4.0	489.7	486.3	473.0	482.0	Surge
4.2	480.4	484.8	467.1	480.1	
4.4	440.1	439.7	443.5	441.1	
4.6	421.4	411.9	424.3	419.1	
4.8	423.3	404.6	428.0	418.8	
5.0	398.3	374.2	380.7	384.1	
4.0	500.9	510.3	508.3	506.8	Sustained
4.2	486.4	480.7	502.2	489.4	
4.4	467.4	453.9	501.5	480.9	
4.6	500.7	491.2	492.4	494.8	
4.8	489.3	475.3	452.7	462.4	
5.0	464.3	411.0	489.5	451.6	

TABLE K.2

TUR Sensitivity

TUR Effect on AUR

<u>TUR</u>	<u>Rep1</u>	<u>Rep2</u>	<u>Rep3</u>	<u>Avg.</u>	
3.5	3.621	3.629	3.676	3.642	Peace
4.0	4.217	4.271	4.249	4.246	
4.5	4.659	4.658	4.618	4.645	
3.5	9.628	9.551	9.610	9.596	Surge
4.0	9.647	9.596	9.616	9.620	
4.5	9.738	9.790	9.731	9.753	
3.5	8.261	7.761	6.912	7.511	Sustained
4.0	9.313	9.809	9.336	9.486	
4.5	8.304	9.851	7.924	9.693	

TUR Effect on Average Work Month

<u>TUR</u>	<u>Rep1</u>	<u>Rep2</u>	<u>Rep3</u>	<u>Avg.</u>	
3.5	68.89	69.42	70.32	69.54	Peace
4.0	80.95	81.37	80.93	81.08	
4.5	88.79	89.28	88.86	89.98	
3.5	146.3	146.3	145.9	146.4	Surge
4.0	146.2	146.1	146.7	146.4	
4.5	147.6	148.2	148.1	148.0	
3.5	109.2	105.7	99.36	108.1	Sustained
4.0	107.7	140.8	103.6	108.0	
4.5	116.9	140.1	113.0	124.0	

TUR Effect on Average Filling Time

<u>TUR</u>	<u>Rep1</u>	<u>Rep2</u>	<u>Rep3</u>	<u>Avg.</u>	
3.5	45.87	45.11	45.91	45.33	Peace
4.0	53.44	54.20	53.91	53.85	
4.5	59.09	59.14	59.69	59.97	
3.5	61.67	60.78	61.41	61.27	Surge
4.0	61.81	61.27	61.51	61.53	
4.5	62.61	61.16	62.89	62.89	
3.5	78.78	70.05	65.36	71.56	Sustained
4.0	88.83	93.72	89.16	90.47	
4.5	78.92	93.77	75.37	92.69	

TABLE K.3

Fly Time Limits Sensitivity

Effect of Fly Time Limits on AUR

<u>FLYLMT</u>	<u>Rep1</u>	<u>Rep2</u>	<u>Rep3</u>	<u>Avg.</u>	
125	3.621	3.629	3.676	3.642	Peace
150	3.573	3.692	3.703	3.656	
125	9.628	9.551	9.610	9.596	Surge
150	9.587	9.598	9.607	9.601	
125	6.261	7.361	6.912	7.511	Sustained
150	6.271	6.048	7.019	6.446	

Effect of Fly Time Limits on Avg Work Month

<u>FLYLMT</u>	<u>Rep1</u>	<u>Rep2</u>	<u>Rep3</u>	<u>Avg.</u>	
125	68.89	69.42	70.32	69.54	Peace
150	68.38	70.26	70.88	69.84	
125	146.9	146.3	145.9	146.4	Surge
150	147.6	146.6	146.4	146.9	
125	115.2	105.7	99.36	108.1	Sustained
150	99.79	86.62	100.2	92.4	

Effect of Fly Time Limits on Avg Fly Time

<u>FLYLMT</u>	<u>Rep1</u>	<u>Rep2</u>	<u>Rep3</u>	<u>Avg.</u>	
125	46.97	46.11	46.91	46.33	Peace
150	45.72	46.72	47.09	46.51	
125	91.67	90.79	91.41	91.27	Surge
150	91.19	91.75	91.90	91.32	
125	76.79	70.05	65.86	71.56	Sustained
150	60.21	57.75	66.84	61.37	

TABLE K.5

Staging Policy Sensitivity
Effect of Staging Policy on AUF

STAGE	Rep1	Rep2	Rep3	Avg.	
30	3.621	3.629	3.676	3.642	Peace
45	3.666	3.677	3.735	3.689	
60	3.676	3.650	3.672	3.666	
30	9.629	9.551	9.610	9.596	Surge
45	9.607	9.629	9.778	9.671	
60	9.468	9.604	9.650	9.574	
30	8.351	7.351	6.912	7.511	Sustained
45	8.661	8.725	8.878	8.852	
60	8.857	8.744	8.902	8.870	

Effect of Staging Policy on Avg Work Month

STAGE	Rep1	Rep2	Rep3	Avg.	
30	68.29	69.42	70.32	69.54	Peace
45	70.16	70.17	71.09	70.47	
60	69.80	70.58	69.92	70.10	
30	145.5	145.7	145.9	145.4	Surge
45	144.8	145.8	146.9	145.8	
60	142.1	143.7	143.7	142.9	
30	142.2	140.7	99.36	108.1	Sustained
45	140.1	140.9	141.9	142.0	
60	142.8	140.5	142.9	142.1	

Effect of Staging Policy on Avg Fly Time

STAGE	Rep1	Rep2	Rep3	Avg.	
30	45.97	45.11	45.91	45.33	Peace
45	46.11	46.75	47.57	46.84	
60	45.63	46.59	46.49	46.57	
30	91.67	90.78	91.41	91.27	Surge
45	91.45	91.62	92.97	92.01	
60	90.02	91.29	91.72	91.11	
30	76.78	70.05	65.36	71.56	Sustained
45	95.00	92.79	97.61	95.60	
60	94.91	92.75	94.27	93.93	

Bibliography

CITED WORKS

1. Armstrong, R.D., Charnes, A., and Samn, S. Aircraft and Crew Scheduling During Airlift. Center for Cybernetic Studies, University of Texas. Austin TX, November 1981 (AD-A114-114).
2. Banks, Jerry and John S. Carson. Discrete-Event System Simulation. Englewood Cliffs: Prentice-Hall, Inc., 1984.
3. "C-5, 141 Crew Ratios Can be Cut -- GAO," Air Force Times, 40:4 (15 October 1979).
4. Chase, Col Ed, AF/XOOTD. MAC Aircrew Ratio Conference. HQ USAF, Pentagon, Washington, DC, 19 Mar 1985.
5. Department of the Air Force. Airlift Operations. MACR 55-1. St. Louis: HQMAC, 14 April 1981.
6. Department of the Air Force. C-141 Operations. MACR 55-141. St. Louis: HQMAC, 15 February 1985.
7. Department of the Air Force. Contingency Planning Policies and Procedures. MACR 28-2. St. Louis: HQMAC, 23 November 1984.
8. Department of the Air Force. Functions and Basic Doctrine of the United States Air Force. AFM 1-1. Washington: HQ USAF, 14 Feb 1979.
9. Fractional Factorial Experiment Designs for Factors at Two Levels. National Bureau of Standards Applied Mathematics Series 48. US Government Printing Office, Washington DC, 15 April 1957.
10. Hartman, Dr Bryce O., School of Aerospace Medicine (USAFSAM). "A Review of USAFSAM Aircrew Ratio Estimation Model." Address to Aircrew Ratio Conference. HQ USAF, Pentagon, Washington DC, 19 March 1985.
11. Hartman, Dr Bryce O., et al., School of Aerospace Medicine (USAFSAM). "Analysis of the Crew Ratio Problem Using Simulation Techniques." USAFSAM, Brooks AFB, TX, September 1971.
12. Honaker, CMSgt, HQMAC Logistics. Personal interviews and C-141 data. Scott AFB IL, May through June 1985.

13. _____. "Military Airlift Command Aircrew Planning Guide." St. Louis:HQ MAC, 1 April 1976.
14. Montgomery, Douglas C. Design and Analysis of Experiments (Second Edition). New York: John Wiley & Sons, 1984.
15. Montgomery, Douglas C., PhD. "Factor Screening Methods in Computer Simulation Experiments". Report to 1979 Winter Simulation Conference.
16. Moses, Maj Glenn, HQ MAC Plans. "C-17 Aircrew Ratio " Address to Aircrew Ratio Conference. HQ USAF, Pentagon, Washington DC, 19 Mar 1985.
17. Moses, Maj Glen, HQMAC Plans. Personal interviews. Scott AFB, IL, 23 November 1984 through 19 September 1985.
18. Myers, Raymond H., Response Surface Methodology. Virginia Polytechnic Institute and State University, 1976.
19. Neter, John, et al. Applied Linear Statistical Models (Second Edition). Homewood: Richard D. Irwin, Inc., 1985.
20. Pritsker, Alan B. Introduction to Simulation and SLAM II. West Lafayette: Systems Publishing Corp., 1984.
21. Russ, Maj Gen Robert D., Director, Operational Requirements, DCS Research, Development, & Acquisition, C-17 Utilization Rates. Staff Study. HQUSAF: Pentagon, Washington DC, 21 October 1981.
22. Stanberry, Maj Wayne, HQ MAC Plans. Personal Interviews. HQ MAC: Scott AFB, IL, Nov 1984 through Nov 1985.
23. Stowell, Robert L. "Estimating Aircraft Utilization Rates." Log Spectrum, 14:16-19 (Spring 1980).
24. Tate, Capt David, HQUSAF Studies & Analysis. Personal interviews. HQUSAF: Pentagon, Washington DC, 19 March through 19 September 1985.
25. Theil, Henri. Principles of Econometrics. New York: John Wiley & Sons, 1971.

OTHER REFERENCES

An Investigation of Blue/Gold Crew Operations. MACRO study, HQ MAC, Scott AFB IL, June 78 (AD-B028 876L).

Garcia, Raul, et al. A User's Guide to the MX Crew Ratio Simulation Model. USAF School of Aerospace Medicine, Brooks AFB, TX, August 1976 (AD-A015 741).

Garcia, Raul, et al. Computer Simulation of Aircrew Management Policies. USAF School of Aerospace Medicine, Brooks AFB, TX, April 1978 (AD-A054 948).

Innis, George and Rextad, Eric, "Simulation Model Simplification Techniques". Simulation. July 1983.

Newman, L.F. Aircrew Ratio Assumptions and Methodology. Air Command and Staff College, Maxwell AFB AL, March 1984 (AD-B084 736).

Samn, Dr Sherwood W. and Dr Bryce D. Hartman, School of Aerospace Medicine (USAFSAM). Personal Interviews. USAFSAM: Brooks AFB, TX, January through August 1985.

UITA

Captain Brian L. Sutter was born on 7 March 1954 in Austin, Minnesota. Upon graduation from high school, he attended the United States Air Force Academy from which he received a Bachelor of Science degree in Mathematics in June 1976. He completed pilot training at Reese AFB, Texas in 1977, and remained there to instruct in the T-37 aircraft until February 1981. He transferred to McGuire AFB, New Jersey where he qualified and progressed to flight examiner in the C-141 aircraft. He entered the School of Engineering, Air Force Institute of Technology in 1984. In December 1985, he graduated and was assigned to the Analysis Branch, Air Force Military Personnel Center.

Permanent address: 601 25th Street S.W.

Austin, Minnesota 55912

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS										
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for Public Release Distribution Unlimited										
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE												
4. PERFORMING ORGANIZATION REPORT NUMBER(S) ~~AFIT/GOR/255/85D-19~~ AFIT/ENS/GOR/85D-19		5. MONITORING ORGANIZATION REPORT NUMBER(S)										
6a. NAME OF PERFORMING ORGANIZATION School of Engineering	6b. OFFICE SYMBOL (If applicable) ENS	7a. NAME OF MONITORING ORGANIZATION										
6c. ADDRESS (City, State and ZIP Code) Air Force Institute of Technology Wright-Patterson AFB, OH 45433		7b. ADDRESS (City, State and ZIP Code)										
8a. NAME OF FUNDING/SPONSORING ORGANIZATION HQ USAF	8b. OFFICE SYMBOL (If applicable) SA33	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER										
8c. ADDRESS (City, State and ZIP Code) Washington D. C. 20330		10. SOURCE OF FUNDING NOS. <table border="1"><tr><td>PROGRAM ELEMENT NO.</td><td>PROJECT NO.</td><td>TASK NO.</td><td>WORK UNIT NO.</td></tr><tr><td></td><td></td><td></td><td></td></tr></table>		PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.					
PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.									
11. TITLE (Include Security Classification) See box 19												
12. PERSONAL AUTHOR(S) Brian L. Sutter, B.S., Capt, USAF												
13a. TYPE OF REPORT MS Thesis	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Yr., Mo., Day) 1985 December	15. PAGE COUNT 104									
16. SUPPLEMENTARY NOTATION												
17. COSATI CODES <table border="1"><tr><th>FIELD</th><th>GROUP</th><th>SUB. GR.</th></tr><tr><td>5</td><td>9</td><td></td></tr><tr><td>15</td><td>7</td><td></td></tr></table>		FIELD	GROUP	SUB. GR.	5	9		15	7		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Transport Aircraft, Military Aircraft, Simulation, Air Force Planning, Military Personnel, Flight Crews	
FIELD	GROUP	SUB. GR.										
5	9											
15	7											
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Title: AN ANALYSIS OF AIRCRAFT RATIOS IN STRATEGIC AIRLIFT-- A SLAM SIMULATION Thesis Advisor: Charles E. Ebeling, PhD., Lieutenant Colonel, USAF Assistant Professor Department of Operational Sciences <i>Approved for public release</i> LAW APR 1984 <i>Lynn E. Wolaver</i> 17 Feb 86 Lynn E. WOLAVER Dean for Research and Professional Development Air Force Institute of Technology (AFIT) Wright-Patterson AFB OH 45433												
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐		21. ABSTRACT SECURITY CLASSIFICATION Unclassified										
22a. NAME OF RESPONSIBLE INDIVIDUAL Charles E. Ebeling, Lt. Col., USAF	22b. TELEPHONE NUMBER (Include Area Code) (513) 255-5302	22c. OFFICE SYMBOL AFIT/ENS										

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

This investigation examined the C-17's mission capability in terms of each aircraft's utilization and that utilization's effect on the aircrew. Specifically, average monthly flying times and average work months, as well as aircraft utilization, were found to be affected by changes in flying time limits, staging policies, target utilization rates, the number of crews, and the launch reliabilities.

The analysis was accomplished through a SLAM simulation of a portion of the MAC airlift system. A single homestation and two homestations were modeled; however, only the single homestation model was analyzed. The output of the simulation was regressed to yield an estimating equation for achieved utilization, average monthly flying time, and average work month for both a NATO and a SNA scenario.

Parameters varied in the sensitivity analysis were crew ratios, target utilization, monthly and quarterly flying limits, and staging policies. Results pointed toward 4.8 crews per C-17 without considering the cost tradeoffs. Staging one crew at an enroute base for every forty-five planned mission transits seemed to be optimal. The results also showed a significant benefit in the sustained phase when the 30/90 day limits were raised to 150/450 hours.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

END

Dtic

7-86